Application to Alter Freshwater Wetlands

Bradford Dam Removal & Fish Passage Restoration
Hopkinton/Westerly, Rhode Island

The Nature Conservancy
Providence, Rhode Island

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FUSS & O'NEILL

317 Iron Horse Way, Suite 204
Providence, RI 02908

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FUSS & O'NEILL

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1 Introduction

Fuss & O'Neill, Inc. (Fuss & O'Neill) and Natural Resource Services, Inc. (NRS) have prepared an Application to Alter Freshwater Wetlands (AAFW) in accordance with the Rhode Island Department of Environmental Management's (RIDEM) *Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act, July 2014* (*Wetlands Regulations*).

The Nature Conservancy of Rhode Island recently received funding from the U.S Fish & Wildlife Service to undertake flood mitigation and the restoration of fish passage on the Lower Pawcatuck River at the White Rock and Bradford Dams. This funding was awarded to the USFWS under the Hurricane Sandy Resiliency Competitive Grant Program administered by the National Fish & Wildlife Foundation for the National Oceanic and Atmospheric Administration (NOAA). This grant was awarded to make the communities along this section of the River more resilient to climate change and anticipated increased frequency and magnitude of flooding in a manner that restores or enhances natural systems.

Since the White Rock Dam was recently removed in Fall 2015, this Project and AAFW addresses the removal of the Bradford Dam (Dam) and replacement with a rock ramp fishway that will better provide river continuity and improve passage of migratory fish species. The removal of the Bradford Dam will eliminate the potential for downstream flood damage resulting from failure of this Dam, will reduce upstream flooding caused by the backwater effects of this Dam while avoiding potential ecological impacts to upstream wetlands and natural resource areas, and will significantly improve successful passage of anadromous and resident fish species through this site to access upstream habitat and spawning grounds by eliminating these impediments to fish migration and improving overall riverine continuity. Targeted anadromous and catadromous species that will benefit from this project include American shad, alewife, blueback herring, and American eel.

1.1 Project Description and Background

The Wood-Pawcatuck River watershed encompasses a total area of approximately 317 square miles and is approximately 25 miles long and 24 miles wide at its widest point. The upper and middle portions of the watershed are relatively rural and characterized by gently rolling hills interspersed with wetlands and ponds. The River is actively used for boating, fishing, and passive recreation and is mostly undisturbed in the impoundment upstream of the Dam.

Two early run-of-the-river dams are located on the main stem of the Pawcatuck River in the project region, both of which currently inhibit or provide sub-optimal fish passage and elevate water levels during normal and flood stages above their historic (pre-dam construction) levels. From downstream to upstream, these dams are the the Potter Hill Dam and the Bradford Dam. A map identifying these dams with the River corridor is provided in the illustration below. The project location is shown within the Pawcatuck River's watershed boundary in *Figure 1* at the end of this report.

For purposes of this report, the project limits include the stretch of the River (and adjoining overbank areas) where water surface elevations will be lowered as a result of the removal of the Bradford Dam. This includes the portion of the River from the railroad bridge downstream of Kings Factory Road, considered to be the Project's upstream limit of hydraulic analysis, to a point approximately 305 feet

downstream of the Bradford Dam, considered to be the Project's downstream limit of hydraulic analysis. Photographs of the dam and adjacent channel sections are provided in *Appendix A*.

Illustration 1: Depiction of the Bradford Dam in respect to the Potter Hill Dam and upstream area

The Bradford Dam is situated approximately 7.0 miles upstream of the Potter Hill Dam. The Dam is constructed on top of what appears to be a natural fall with ledge, boulders, and large cobble found immediately below the spillway. The Dam is a run-of-the-river type dam with a principal spillway spanning most of the width of the River. A raised 7.8-foot wide by 2.5-foot high masonry block section of the Dam divides the spillway into two segments: a 42.0-foot left segment and a 41.7-foot right segment. The Dam has a maximum structural height of approximately 10 feet and an approximate 6-foot hydraulic height. The Dam impounds water approximately 5.0 miles upstream under base flow conditions.

Illustration 2: Aerial of the Bradford Dam and Denil Fishway.

The Dam has been retrofitted with a 4-foot wide Denil fishway that provides the only means for fish passage at this location. As reflected in *Illustration 2*, the Denil fishway is located on river right with its entrance just

downstream of the spillway. The fishway was built by RIDEM in 1981 and was modified by WPWA, NRCS, and USFWS in 2008. The fishway consists of two sloped wooden baffle sections. The upper section was constructed at a 1(V):8(H) slope and the lower section was constructed at a 1(H):9.34(V) slope (after being altered in 2008). The width of the fishway reduces to approximately 2.5 feet in order to increase the velocity of flow (create attraction) at its entrance. Stop log slots are also present at the fishway entrance. The alignment of the entrance is perpendicular to the spillway face and points directly into a gravel bar as reflected in *Illustration 3*.

Based on USFWS's assessment of hydraulics at the Bradford Dam (as published in their *Draft July 2014 Evaluation of Fish Passage Efficiency Report*), suitable fish passage does not exist at this fishway due to inadequate flow depths in the fishway during minimum operating conditions, inadequate attraction flow velocities during all flows expected during the fish passage migratory window, and improper alignment of the fishway entrance. Entrance alignment is essential to an effective fishway. Improper alignment can cause the attraction signal to become lost within zones of turbulence or be directed into areas that fish will not be able to recognize. The alignment of the Bradford entrance is not ideal due to the gravel bar situated directly downstream. This gravel bar dissipates the energy of the signal and limits the approach depth from downstream.

Illustration 3: Depiction of the Bradford Dam Fishway Entrance

A historic mill building (the Mill Building) is located adjacent to the Dam and the River and is supported by a vertical retaining wall constructed of ledge and stacked stones on river left. The stability of the Mill Building is a concern, especially during flood flows.

In considering project goals (of flood resiliency and fish passage), ecological benefits, potential impacts to upstream natural resource areas, and after seeking input from project partners including the USFWS, the following three fish passage alternatives were selected for further analysis as part of this project:

- Full Dam Removal – This alternative proposes the full removal of the Dam to restore that natural channel bed that existed prior to the construction of the structure.
- Partial Dam Removal – This alternative proposes the removal of the right side the dam (only) and the Denil fishway to restore a portion of the natural channel bed, while the left half of the dam would remain in place to protect the left riverbank and the Mill Building during flood flows.

- Dam Removal with Installation of Full-Height Rock Ramp and Grade Control Structure - This alternative proposes the removal and replacement of the Dam and existing Denil fishway with a rock ramp system and new grade control structure designed to provide effective fish passage while resulting in minimal impacts to headpond water levels and upstream natural resource areas. To achieve this, the crest of the grade control structure is designed with notches to provide safe and effective fish passage and a top (crest) elevation slightly lower than that of the existing Dam.

After initial hydraulic analyses of each of the alternatives was completed, Fuss & O'Neill conducted meetings with TNC, RIDEM Fish and Wildlife, NOAA, WPWA, and BPF Realty LLC, to review preliminary findings at which point the benefits, impacts and costs associated with each of the three alternatives was reviewed. The principal project constraint identified, which ultimately proved to be the primary driver in the selection of the proposed fish passage alternative, was related to the potential impacts that lowering headpond water levels would have on the freshwater wetlands, bridges, and the public boat launch (Boat Launch) upstream of the Dam.

The Dam impounds water approximately 5.0 miles upstream under base flow conditions. As a result, portions of the Grills Sanctuary Preserve, Burlingame Wildlife Management Area and numerous bordering wetland systems upstream of the Project Site could potentially experience conversions or reductions of wetlands if base condition water levels were to drop significantly (or more than six inches). Additionally, the Route 91 Bridge, located immediately upstream of the Dam's spillway, is subject to scour damage from the Pawcatuck River. Any fish passage alternative that would substantially lower the upriver water surface elevation could potentially affect water velocities at the base of the bridge, and impact water levels at the Boat Launch. It was, therefore, determined that the fish passage alternative selected must minimize upriver water surface elevation changes or otherwise be developed in tandem with assessment and modifications to the Route 91 Bridge to ensure the bridge's integrity and the Boat Launch to ensure its function is not impaired during expected seasonal low flows in this portion of the River.

Other ancillary project constraints that were discussed at project review meetings with the project partners included the following:

- Potential Effects on Existing Riverbanks and Structures Adjacent to the River: Lowering water levels upriver of the Dam could potentially have impacts on riverbank stability where steep channel banks are adjacent to developed properties, particularly adjacent to the Dam where a retaining wall supports the Mill Building. In addition, it is possible that additional scour protection would be required to adequately protect abutment structures at the two railroad bridge crossings over the River upstream of the Dam.
- Potential Effects on Existing Groundwater Supply Wells: Lowering river levels could potentially affect the yield of groundwater supply wells proximate to the River, particularly dug wells which may exist and may be currently marginally functional, where a relatively minor reduction in river level may reduce a well's capacity to provide water at the same rate and under the same conditions as currently. Through review of this potential issue with the project partners, it was decided that while a more detailed study could technically be undertaken to evaluate this issue further, which may determine that no wells would be affected by a full dam removal, funding limitations and scheduling constraints precluded undertaking this study.

Fuss & O'Neill's major findings from its preliminary alternative hydraulic analyses were as follows:

- **Performing a partial or full dam removal with no rock ramp fishway or upstream grade control structure will result in significant reductions in base condition water surface elevations (of greater than six inches) from the Bradford Dam up to the remnants of the Burdickville Dam.**

  Performing a partial or full dam removal (only) would reduce base condition (dry-weather condition) water surface elevations immediately upstream of the dam by approximately 5.0± feet. Reductions of greater than six inches would extend approximately 3.9 miles upstream of the Bradford Dam (up to the Burdickville Dam) during base flow conditions. This substantial reduction in base condition water surface elevations could potentially impact structures (the Route 91/216 Bridge, two Amtrak Bridges, and the Burdickville Road Bridge), upstream boat launches, and adjacent and upstream bordering wetland systems including an upstream natural heritage area. This natural heritage area contains a wetland complex that is considered a coastal plain quagmire (state critically impaired and globally vulnerable), coastal plain floodplain swamp (state critically imperiled), acidic level fen (state imperiled), and acid level bog (state vulnerable). These habitat areas also contain known species of state-endangered plants, a state threatened plant, and many state concern plants.

- **Performing a partial or full dam removal (only) will also require further in-river channel improvements (e.g. channel bottom excavation, the incorporation of weirs or other similar minor grade control features) in order to reduce flow velocities and increase flow depths just upstream of the Bradford Dam in order to facilitate safe and effective fish passage.**

- **Although performing a partial or fall dam removal will result in flood elevation reductions for the smaller and more frequent flood events such as the 2-year flood, it will not result in significant reductions in flood elevations during the more significant flood events such as the 100-year flood.**

  For example, a full dam removal (with no rock ramp fishway and grade control structure) would result in 2-year flood elevation reductions of approximately 1.7 feet immediately upstream of the Bradford Dam. However, it would only result in 100-year flood elevation reductions of approximately 0.12 feet. The reason that there will be minimal flooding benefits realized during larger flood events such as the 100-year flood is because of the significant backwatering impacts that the Potter Hill Dam has on tailwater elevations experienced downstream of the Bradford Dam. The Potter Hill Dam is located approximately 7.2 miles downstream of the Bradford Dam. The Potter Hill Road Bridge, the Route 3 Bridge, and the elevated stream channel bottom between both bridges also contribute to raised tailwater elevations at the Bradford Dam (all of which our outside of the limits of this Project).

- **The only way to substantially improve flooding in the vicinity of the Bradford Dam and area upstream during the more significant flood events (such as the 100-year flood) would be to remove the Potter Hill Dam in tandem with the Bradford Dam.**

The results of initial hydraulic analyses revealed that the removal of the Potter Hill Dam would result in an approximate 0.5-foot reduction in 100-year flood elevations immediately upstream of the Bradford Dam and Route 91 Bridge.

- **Due to the presence of sensitive wetland systems, an upstream natural heritage area containing State endangered and threatened plant species, and minimal flood benefits anticipated upstream of the Bradford Dam during the greater magnitude flood events such as the 100-year flood under the partial or full dam removal alternatives; a full dam removal alternative in conjunction with the installation of a rock ramp fishway and upstream grade control structure was explored.**

  This alternative proposes the installation of a rock ramp fishway along with an upstream grade control structure designed to limit upstream reductions in base condition water surface elevations to six inches or less. This would significantly minimize potential impacts to structures, boat launches, and sensitive wetland systems/natural resource areas upstream of the Dam. While a rock ramp fishway with a grade control structure would only result in approximately 0.2-foot reductions in water surface elevations experienced upstream of the Dam during the 2-year flood (as opposed to 1.7 feet under the partial or full dam removal scenarios), it would provide an approximate 0.10-foot reduction during the 100-year flood. This is approximately the same reduction (within 0.02 feet) as the full dam removal alternative during the 100-year flood.

Through discussions of these preliminary results and other constraints amongst TNC, NOAA, USFWS, and BPF Realty LLC, it was determined that it was the project partners' intent to pursue an alternative that best balances the Project's goals and objectives including maximizing fish passage efficiency while protecting adjacent and upstream existing structures, uses, and natural resources at the site and within the surrounding river and wetland system. Although flood protection was a major consideration, it was concluded that the Potter Hill Dam (which is outside of the limits of this Project) would need to be removed in order to achieve more substantial flood elevation reductions (of six inches or more) during the more significant flood events such as the 100-year flood. This is because of the significant backwatering impacts that the Potter Hill Dam has on tailwater elevations experienced downstream of the Bradford Dam during the more significant flood events.

As a result, the alternative selected by the Team to provide safe/effective fish passage while achieving limited flood protection benefits and protecting upstream structures and natural resources is the full dam removal with the construction of a full-height rock ramp fishway. This alternative currently provides the best balance of the Project's goals and objectives. If it is decided in the future that Potter Hill Dam can be removed, the same 100-year flood reductions upstream of the Bradford Dam (of 0.5-feet) would still be realized with or without the rock ramp fishway in-place.

Information documented herein is intended to serve as the Written Evaluation portion of the AAFW, as described in *Section 10.02* of the *Wetlands Regulations*. Fuss & O'Neill and NRS have prepared this Written Evaluation on behalf of TNC and its project partners.

1.2 Project Purpose

Since the USFWS's *Draft July 2014 Evaluation of Fish Passage Efficiency Report* concludes that the entrance conditions of the structure do not meet USFWS Fish Passage Engineering best practices for a properly operating fish passage structure, the purpose of this project is to remove the Bradford Dam and Denil fishway and replace it with a rock ramp fishway, thereby improving river continuity for migratory fish and other aquatic organisms, avoiding ecological impacts to sensitive upstream wetland/natural resources areas, and marginally reducing the risk and severity of flooding adjacent to and upstream of the Dam during wet-weather events. These elements are described in further detail in the sections below.

1.2.1 Improved Fish Passage

According to the document *Strategic Plan for the Restoration of Anadromous Fishes to Rhode Island Coastal Streams* prepared by RIDEM, and accounting for the recent removal or adaptation of the three furthest upstream dams, five dams remain on the main stem of the Pawcatuck River. The dam furthest downstream, the Stillman Mill Dam in Westerly, has breached and is passable to diadromous fish. The White Rock Dam, which was previously located upstream of the Stillman Mill Dam, was recently removed by TNC in Fall 2015 in order to improve fish passage at this location. The next two dams upstream of the former White Rock Dam are the Potter Hill and Bradford Dams. Both of these dams have been retrofitted with Denil fishways, but do not provide suitable fish passage throughout the entire migratory fish passage season.

Based on USFWS's assessment of hydraulics at the Bradford Dam (as published in their *Draft July 2014 Evaluation of Fish Passage Efficiency Report*), suitable fish passage does not exist through this portion of the River due to inadequate flow depths during minimum operating conditions, inadequate attraction flow velocities during all operating flows, and improper alignment of the fishway entrance in respect to the downstream natural river channel. As a result, one of the primary purposes of this project is to remove this Dam and restore flow to the natural river channel via the installation of a rock ramp fishway. This, in turn, will restore river continuity for migratory fish and other aquatic organisms.

Between 2010 and 2013, the Lower Shannock Falls Dam, the Horseshoe Falls Dam, and the Kenyon Mill Dam have been either removed or modified to improve fish passage. These projects have opened up approximately 10 stream miles of spawning and nursery habitat approaching Wordens Pond. Additionally, the White Rock Dam was recently

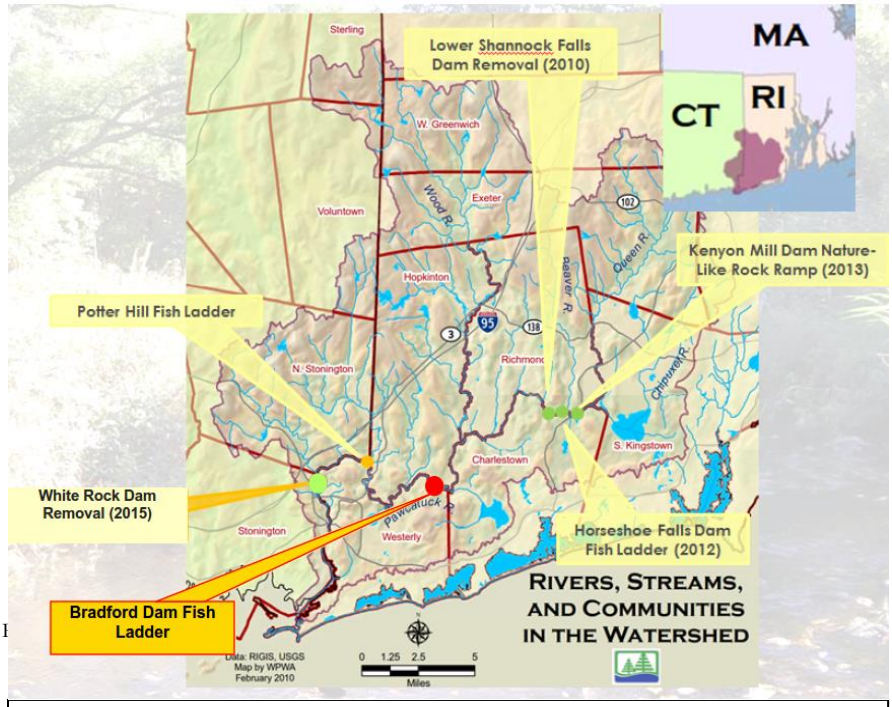

Illustration 4: Depiction of the River Corridor, Watershed Boundary, Completed Restoration Projects, and the location of Bradford and Potter Hill Dams

removed in Fall 2015 restoring natural river channel continuity from Little Narragansett Bay to the Potter Hill Dam. Refer to *Illustration 4* for a depiction of each of these dams in respect to their locations within the Watershed.

Provisions for improved fish passage at the Bradford Dam, and subsequently the Potter Hill Dam, would significantly improve upstream and downstream migration of diadromous and catadromous fish species through the entire main stem of the River for a distance of approximately 31 miles between the mouth of the River (at its downstream end) and Wordens Pond in South Kingstown (at its upstream end). According to the *Strategic Plan for the Restoration of Anadromous Fishes to Rhode Island Coastal Streams*, this and other planned projects would be in support of opening up an additional 1,300 acres of habitat associated with the River including Wordens Pond.

As identified in USFWS's *Draft July 2014 Evaluation of Fish Passage Efficiency Report*), anadromous species of major concern (project target species) on the River include the American shad, alewife, and blueback herring. Each has a specific upstream migratory period as shown in the table below (altered from MEDOT, 2008 through personal communication with RIDEM personnel in 2014).

In Rhode Island, river herring (alewife and blueback herring are collectively referred to as river herring) tend to undertake upstream migration between March 1st and June 1st, peaking in April. Shad typically migrate between April 1st and July 1st, peaking in May. As a result, the extent of the upstream migration season for the project's target species is March 1st to July 1st. For purposes of this project's analysis and design, the upstream migration period used for evaluation of river channel flows was taken from March 15th through June 15th per guidance from USFWS and RIDEM staff.

Table 1: Migratory Periods for the Target Species in the Pawcatuck River

Table of Target Species in the Pawcatuck River Drainage *altered from Maine DOT Table 4 Migratory Periods and Swimming Requirements for Maine Fish Species

Species, life stage	Direction of Travel (upstream (U) Downstream (D)	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
First half of month = 1 Second half of month = 2		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Alewife, adult	U					■	■	■	■	■	■	■													
American shad, adult	U						■	■	■	■	■	■		■	■										
Blueback herring, adult	U					■	■	■	■	■	■	■													

As a result, the removal and replacement of the Bradford Dam with a rock ramp fishway will restore anadromous and resident fish species habitat by eliminating the Dam as an impediment to fish migration and restoring riverine connectivity at the Project Site. The removal of the Dam and replacement with a rock ramp fishway will also reduce the potential for downstream flood damage upon failure of this Dam and will provide benefits in terms of upstream flooding caused by the backwater effects of this Dam.

1.2.1.1 Historic Fisheries

A 2006 feasibility study conducted for the WPWA notes that the Pawcatuck River is a regional importance river system for diadromous fisheries, including Atlantic salmon and American shad. The system may have also have historically supported a significant brook trout population. One hypothesis is

that the salter brook trout were mistaken for Atlantic salmon, leading some to question whether Atlantic salmon truly was a significant species in the Pawcatuck River watershed (WPWA 2005). Other diadromous fish in this system include alewife, blueback herring, rainbow smelt, and sea-run brown trout, as well as the American eel, a catadromous species (USFWS, 1991).

The first known users of the Pawcatuck River were the Native American Indian tribes of Niantic, Pequot, and Narragansett, who hunted and fished throughout the extensive watershed. With the introduction of European colonists in the 1600s, activities along the banks of Rhode Island's rivers shifted to residential and commercial uses. Water powered mills were introduced - initially grist mills used to grind grains for flour, which were eventually converted to textile mills that processed wool and cotton. Wastewater from these mills was often discharged directly into the River (Desbonnet and Schneider, 1992). These and other anthropogenic activities over the last several centuries have resulted in significant physical and ecological alterations of the river.

The impacts to anadromous and resident fisheries habitat resulting from construction of the dams has been the focus of significant efforts to restore river continuity and river habitat for anadromous and catadromous species in Rhode Island's coastal waters. River herring broodstock is transplanted by the DFW into areas where fish passage is already established. The Pawcatuck River watershed is stocked with hatchery-reared Atlantic salmon fry, parr, and smolts (Erkan, 2002). In addition to these efforts, fish passage improvement projects (as previously discussed) have been recently completed at several dams on the main stem of the Pawcatuck River, building on previous construction of fish ladders in at the Bradford and Potter Hill dams.

The Pawcatuck River watershed bas also been identified in the *Strategic Plan for the Restoration of Anadromous Fishes to Rhode Island Coastal Streams* as having the potential for restoration of anadromous species (Erkan 2002). The Pawcatuck River is the only watershed identified in the plan as having the potential for significant areas of salmon habitat. The plan acknowledges that fish passage improvements on the main stem of the Pawcatuck River would result in significant expansion of potential river herring and American shad spawning habitat.

A number of studies have also been undertaken by and for the Wood-Pawcatuck Watershed Association (WPWA), including a study on the temperature effects of small dams in low order streams indicate that small dams elevate downstream water temperatures and that channel temperature may remain elevated for miles downstream (*Maximum Stream Temperature Estimation from Air Temperature and its Relationship to Brook Trout*, Saila, 2004). Supporting data was collected downstream of a small (four-foot) dam on the Beaver River, a tributary to the Pawcatuck River.

A separate study assessed habitat requirements for brook trout in low order streams. Data from that study indicate that the proximity of the sample site to dams was important in determining the relative proportion of brook trout in the sample. The report hypothesizes that the presence of dams not only obstructs seasonal movement but also increases suitable habitat for warm-water fish species. Competition from these warm-water species may result in the reduced growth and survival of brook trout (*Small Dams and Habitat Quality in Low Order Streams*, Saila, 2005).

A study of the interactions among fish species in the Pawcatuck watershed indicates that brook trout abundance is increased in situations where competition by other species is minimized. Data was

collected from Locke Brook, Beaver River, Breakheart Brook, and Brushy Brook. Additionally, species composition was found to be influenced by altered environmental conditions in which warm-water species were associated with stream reaches in relative close proximity to impoundments (*Interspecific Association, Diversity, and Population Analysis of Fish Species in the Wood-Pawcatuck Watershed.*, Saila, et. al., undated).

These studies collectively support the conclusion that, in addition to obstructing fish migration, dams located within the Pawcatuck River watershed disturb the River's natural course and flow, change water temperatures in the River, alter the River's floodplains, disrupt river continuity for aquatic species and alter the natural transport of sediment by the River's normal and flood flows. Such changes likely have reduced and transformed environmental conditions and the biological character of the River, isolating populations of fish and wildlife and their habitats, impacting fish species composition and populations.

1.2.2 Flood Risk Reduction

Since the late 1700's, the Pawcatuck River (River) has been physically and ecologically altered as a result of human activity including the installation of several dams which have elevated normal- and flood-induced water surface elevations along certain sections of the River. Most recently, significant flooding occurred along all basins of the Wood-Pawcatuck river system, most severely affecting developed areas, including the urban district and nearby development in Bradford, Rhode Island.

The U.S. Army Corps of Engineers (USACE) has undertaken several studies and projects to address flooding impacts along lower portions of the Pawcatuck River in Westerly and Stonington, including development of a levee/pump station flood protection barrier in Pawcatuck, Connecticut downstream of Westerly's urban district. The USACE is currently undertaking a Flood Risk Management Study, which includes consultation with municipalities bordering the River in Connecticut and Rhode Island. The goal of this project is to identify areas most significantly affected by flooding caused by the River and to subsequently identify projects/modifications that could reduce or mitigate flooding impacts.

One of the principal elements of the study is to evaluate lowering of base flood elevations along the river through removal of dams that are no longer serving their intended purpose, and do not provide flood benefits through storage of flood flows. The Bradford Dam is a run-of river dam but is no longer serving its intended purpose; the dam instead exacerbates flood conditions during significant storm events. The removal and replacement of the Dam with a rock ramp fishway will lower flood elevations upstream of the Dam during significant storm events.

Lastly, it is noted that the Dam impounds a large volume of water, which if released in an uncontrolled manner, would present a hazard to persons, properties and infrastructure directly downstream of the dam. Without significant upkeep and maintenance in the future, over time the Dam will deteriorate and may catastrophically fail, possibly resulting in damage to downstream properties and infrastructure as well as ecological harm. Removal of the Dam and replacement with a rock ramp fishway will avoid the hazards and potential harmful effects that failure of the dam present, in addition to the reductions of 100-year flood elevations for residents and properties upstream of the Dam.

1.3 Project Overview and Improvements

Proposed work areas and activities are shown on the drawing set provided with this permit application as outlined below.

- Drawing CS-101 depicts the overall Project's limit of disturbance and provides a general map index for the drawing set.
- Drawing CS-102 depicts existing conditions including existing topography, wetland features, and the 100-year floodplain boundary as determined through hydraulic analysis.
- Drawing CS-103 depicts the proposed construction accesses, staging/storage area, and overall limit of disturbance with respect to on-site and adjacent wetland resource areas.
- Drawing CS-104 depicts the existing features within the Project's limit of disturbance that are proposed to be demolished (including the existing dam structure and Denil fish ladder) as well as proposed erosion and sedimentation controls.
- Drawing CG-101 depicts the layout of the proposed project improvements including the proposed topography and rock ramp fishway. This drawing also reflects the profile of the rock ramp fishway (with upstream grade control structure) and areas of in-river sediment excavation/relocation.
- Drawing CL-101 depicts the in-stream and riparian restoration plan.
- Drawing CP-101 shows the general sequence of construction for proposed activities, including provisions for control of water and site access.
- Drawings CD-501 through CD-503 depict construction details supporting the construction of rock ramp fishway features.

The following paragraphs generally describe planned work activities, areas, and temporary and permanent modifications proposed under the project.

1.3.1 Temporary Work Areas/Modifications

Primary site access will be established through the use of an existing cleared access path from Route 91/216 located on the northern side of the River. Since limited clearing of vegetation and the installation of erosion and sedimentation perimeter controls. The existing clearedWoody vegetation will be cleared from the primary access route in Hopkinton, Rhode Island proposed through the Denil fishway access route off of Route 91owned by BPF Realty described below.

- Primary/Secondary Site Accesses and Temporary Staging/Storage Area
    - Primary access for construction vehicles/equipment will be gained via an existing historic cart path upstream of Bradford Dam on river-right in Hopkinton, Rhode Island. This access route, visible in aerial photographs from 1972 in *Appendix B*, and extends from Alton Bradford Road (Route 91) through BPF Realty's property to the current location of the fish ladder in order to facilitate the removal and disposal of the fish ladder, the construction of the temporary diversion channel, and provide access to the main river channel from river right.
    - Potential secondary access for construction vehicles/equipment will be gained via an existing grassed road upstream of Bradford Dam on river-left at the site formerly known as

the Bradford Industrial Park, in Westerly, Rhode Island, visible in aerial photographs dating back to 1939, included in *Appendix B*. This access route will extend from Alton Bradford Road (Route 91) through BPF Realty's property to the upstream end of the millrace channel in order to gain access to the millrace and main river channel from river left.

- A temporary upland staging and storage area, located in a previously disturbed open space on BPF Realty's property on river right, will provide an approximate 63,000 square feet for the contractor's potential use, as needed. This area is visibly disturbed in aerial photographs dating back to 1939, included in *Appendix B*. No clearing will be conducted within the temporary staging and storage area. The staging area will be returned to its existing condition.
- The previously cleared paths where the access routes will be constructed consist primarily of grassed surfaces. These access routes will be restored to their original vegetative condition following construction using either native conservation or wetland seed mixes as specified on the *In-Stream & Riparian Habitat Restoration Plan*.

- In-Channel Work Area
  - In-channel work will include the removal of the dam structure and remnant concrete, stones, and sediment from upstream and downstream of the dam; construction of a permanent rock ramp fishway above and below the location of the remnant dam structure; construction of a permanent earthen barrier at the upstream end of the millrace channel on river-left; and placement of fill and slope stabilization measures along river left to better protect BPF Realty's structure and property from flood damage.
  - The work area to complete temporary channel modifications within the river channel will extend from approximately 220-feet upstream of the Bradford Dam to approximately 300-feet downstream.
  - Areas of the channel outside of the limits of the rock ramp fishway that will be temporarily disturbed will be restored to open water habitat with channel bottom features and grading that will match existing conditions.
- Upstream and Downstream Water Control Systems and Temporary Flow Diversion Channel
  - During construction of in-river improvements, sheetpiling installed to function as the rock ramp fishway's upstream cutoff and upstream grade control structure will serve as the primary upstream water control system.
  - A temporary cofferdam will also be installed across the River channel downstream of the proposed work area. This temporary cofferdam will extend from the right bank of the River to the left bank near the downstream end of the mill building immediately adjacent to the river. This cofferdam is expected to be constructed of bulk sandbags and plastic liners and will be removed in its entirety following completion of construction.
  - The upstream and downstream water control measures will allow regrading of the natural river channel and construction of the rock ramp fishway under a dewatered condition. The upstream sheetpiling system in conjunction with the downstream cofferdam system will prevent significant flows within the natural river channel during construction. The upstream

sheetpiling cofferdam system will also function to divert main river flows into the temporary bypass channel.

- A temporary bridge constructed across the temporary bypass/flow diversion channel will provide construction vehicle/equipment access to the natural river channel during dam removal and during work within the river channel. Abutments for the bridge will be constructed of timber crane matting.
- Water leakage through the upstream and downstream cofferdam system and from groundwater will be pumped from respective work areas into temporary dewatering areas located between the main river channel and the temporary diversion/bypass channel. Discharge from these dewatering areas will be pumped through filter bags (for pretreatment and sediment removal) prior to being discharged to the temporary diversion/bypass channel.
- Work performed within the River's natural channel and Millrace, including dam removal, excavation/grading of river sediment, construction of the rock ramp fishway, and restoration/stabilization of riverbank areas, will occur in dewatered conditions after the sheet pile is installed. As the sheet pile is a permanent component of the rock ramp fishway, it will stay in place once all work is completed.

1.3.2 Permanent Work Areas/Modifications

- Existing Dam Spillway and Adjacent Fish Ladder Removal
  - The dam and its spillway will be removed to within 25-feet of the existing building structure on the river left in addition to the adjoining fish ladder, adjacent fill/sediment above proposed grade, and any legacy dams uncovered during construction. Concrete, timbers, and steel reinforcing will be properly disposed of off-site and excavated channel sediment and stone may be used as channel fill to construct the permanent earthen barrier at the upstream end of the millrace channel or as soil-fill for the proposed channel bottom and stone slope protection.. Stone meeting the pertinent design requirements may be reused to build the fishway weirs or as stone armor channel bottom or slope protection.

    Documentary photographs of the exposed structure are expected to be required following dewatering and prior to demolition, as part of ongoing Section 106 compliance activities currently being coordinated with the Rhode Island State Historic Preservation Office.
- Channel and Riverbank Excavation
  - In order to avoid increases of 100-year base flood elevations (BFEs) within the restored river channel, the majority of the rock ramp was constructed upstream of the dam within the current headpond. The channel bottom downstream of the former dam also required excavation in order to avoid localized increases in BFEs downstream of the dam and to accommodate the necessary pool depths between downstream rock weirs in order to meet current fish passage design criteria, The extent/depth of sediment removal, has been confirmed through hydrologic/hydraulic modeling of flood flows in the river channel.
  - Excavated in-river sediment from the river channel is expected to be relocated as follows:

- to create the core of the earthen barrier that is proposed across the inlet of the millrace channel where it will subsequently be stabilized by placement of stone armor protection and topsoil, and seeded to establish vegetation;
- to fill voids of soil-filled stone armor channel bottom and slope protection below the base condition water surface elevation.

o Excavated upland sediment from riverbank areas is expected to be relocated as follows:

- to create the upper layer of the earthen barrier that is proposed across the inlet of the millrace channel where it will subsequently be stabilized by placement of stone armor protection and topsoil, and seeded to establish vegetation;
- to fill voids of soil-filled stone armor channel bottom and slope protection above the base condition water surface elevation.

It is expected that a total of approximately 4,950 cubic yards of soil materials including in-river and upland sediment and/or rock are to be excavated within the project area. Of this total amount of material to be excavated, it is expected that approximately 1,440 cubic yards of this material is to be utilized as fill material in creating stable channel bank areas on river right and river left, approximately 350 cubic yards are to be utilized in the construction of the permanent cutoff at the inlet of the millrace channel, and approximately 890 cubic yards will be used in raising the existing channel bottom to proposed grade. This will result in an excess of approximately 2,270 cubic yards of cut material. This excess in excavated material will be spread uniformly across portions of the temporary staging area that are above/outside the 100-year floodplain boundary, in accordance with the results of sediment testing performed as part of this project's investigation and evaluation of the project area.

- Rock Ramp Construction
  - A permanent fishway will be constructed upstream and downstream of the dam following its removal. The fishway will consist of a series of pools and weirs constructed of soil-filled stone, extending from just upstream of the Millrace channel to the downstream end of the current Dam Location (approximately between Sta. 0+10.6 to Sta. 3+33.7 in reference to the construction baseline reflected on Sheet CG-101).
  - It is estimated that approximately 7,000 cubic yards of soil-filled stone armor protection is to be placed within the channel area. Rock excavated from the channel will be reused in constructing the structure where feasible.
  - The work area required to complete permanent channel modifications within the river channel will extend from approximately 190-feet upstream of the Bradford Dam to approximately 300-feet downstream.
- Stone Armor Slope Protection
  - Channel bank areas disturbed by construction will be stabilized to resist erosion. Slope areas below the base condition water levels will be stabilized with soil-filled stone armor slope protection; slope areas between base condition and 2-year water levels will be restored with live stakes and soil-filled stone armor slope protection; and slope areas above the 2-year water level will be restored with long-term 100% biodegradable erosion control blanketing and native wetland or conservation seed mixes (depending on location).

- It should be noted that the top bank elevation on river left will be raised to protect the foundation of the adjacent Mill Building during high flows and flood events.

- Millrace Cutoff Construction
  - A permanent, scour-resistant earthen fill barrier will be constructed across the upstream end (inlet) of the Millrace. Construction of this permanent feature will occur once the Dam has been fully removed and the rock ramp constructed, and before flows are restored to the main river channel.
  - The barrier will be constructed of excavated in-river sediment and stabilized with soil-filled vegetated stone armor. A control structure consisting of a headwall and sluice gate will be constructed to allow the property owner to control the flow of water into the Millrace.

Erosion Control Blanketing and Vegetation over Exposed Channel Banks

- Long-term erosion control blanketing (100% biodegradable) will be installed and seed placed along left and right sloped riverbank areas above the bankfull (or 2-year flood) water levels. This long-term erosion control blanketing shall last for a minimum of 36-months in order to allow vegetation to adequately establish through a few growing seasons before biodegrading
- Native seed will be installed as indicated on the *In-Stream & Riparian Habitat* Restoration Plan (Sheet CL-101) on all sloped and flat riverbank areas to receive blanketing.

These proposed habitat restoration activities will have permanent and temporary impacts to jurisdictional wetlands in Rhode Island as summarized in the following table.

Table 2: Temporary and Permanent Wetland Resource Impact Areas

	Flagged Wetlands (square feet)	Riverbank or Perimeter Wetlands (square feet)	Riverine (square feet)
Activity Resulting in Temporary Impacts within Limit of Disturbance			
Construction Access Routes, Temporary Staging/Storage Area, Water Control System Installation, and Other Improvements that Will Not Result in Permanent Change in Grading or to Character of Wetlands	10,940	24,020	5,760
Activity Resulting in Permanent Impacts within Limit of Disturbance			
Removal of Bradford Dam and Denil Fish Ladder, Construction of Rock Ramp Fishway, Regrading and Stabilization of Riverbank Slope Areas, and Installation of Earthen Barrier Across Millrace Inlet	3,730	29,560	62,220
Total Disturbance within Limit of Disturbance	14,670	53,580	67,980

In order to fully assess project alterations resulting from changes in base condition water surface elevation and 100-year base flood elevation changes, the HEC-RAS hydraulic modeling limits for this

project were established as described below:

- from a point approximately 823 feet (or 0.16 miles) downstream of the Bradford Dam referred to herein as "the downstream limit of study;"
- to a point approximately 3,635 feet downstream of the King's Factor Road Bridge (or 6.46 miles upstream of the Bradford Dam) referred to herein as "the upstream limit of study."

These are the limits where upstream and downstream convergence is achieved between the pre- and post-condition hydraulic models. It is important to note, however, that the rock ramp fishway has been designed with an upstream grade control structure that will:

- limit upstream reductions in base condition water surface elevations to less than six inches; and
- avoid increases in 100-year flood elevations.

Minimizing changes in base condition water surface elevations to less than six inches will avoid significant ecological changes to sensitive upstream wetland systems. Avoiding increases in the 100-year flood elevations will avoid any adverse impacts to adjacent properties in terms of flooding and flood insurance; the proposed design will actually result in minor reductions in upstream water surface elevations during flood events.

The range of impacts to base condition and 100-year water surface elevations varies with respect to distance upstream of the Dam. *Figures 5A through 5G* depict the locations of cross sections included in the hydraulic model as well as the pre- and post-condition base condition and 100-year water surface elevations.

1.4 Compliance with Other Regulatory Programs

This project qualifies under Category II of the US Army Corps of Engineers (ACOE) Programmatic General Permit (PGP) for wetland restoration projects; it is understood that it will undergo concurrent state reviews for the issuance of Section 401 Water Quality Certifications in Rhode Island, through the filing of RIDEM permitting materials, in addition to being reviewed by RIDEM under its Wetlands Regulations.

The USFWS is the project's lead federal agency undertaking outreach and coordination with State Historic Preservation Offices (SHPO) in and Tribal Historic Preservation Offices (THPO) in Rhode Island under Section 106 of the National Historic Preservation Act (NHPA). Outreach letters have been transmitted to potentially interested THPOs. In addition review of the project is being conducted by the Rhode Island SHPO, as the dam is an element of the designated Bradford Village Historic District. TNC is continuing to coordinate with the Rhode Island SHPO's review of the project and will coordinate compliance under Section 106 of NHPA with USACE, as required.

2. Wetlands and Wildlife Assessment

Natural Resource Services, Inc. (NRS) performed a study of the Pawcatuck River and its associated wetlands that occur in and around the location of the Bradford Dam. The purpose of this study was to evaluate the current conditions and related habitat values of the project area in order to determine the possible impacts that the project would have on the regulated state jurisdictional wetlands.

Information and additional evaluations conducted by Fuss & O'Neill, Inc., which consisted of detailed river passage modeling, provide the foundation for post-dam removal site conditions used in preparation of this narrative. As such, the following information presents the wetland values currently offered by the identified project area, the impacts that the dam removal may have and all design methods and measures that have been proposed to mitigate any potential impact to, or loss of, existing wetland values and habitat.

In addition, TNC has provided additional habitat information of upstream areas that may be impacted by changes in water level. As such, the project has been configured to feature a grade control structure to maintain a similar water elevation to that at pre-development levels, thus ensuring the long-term stability of any sensitive upstream habitats.

2.1 Evaluation Methodology

NRS performed a site inspection and delineation within the immediate vicinity of Bradford Dam (RIDEM Dam No. 253) and to assess wetland habitats located along those reaches of the Pawcatuck River where water levels could be impacted as a result of the installation of rock ramps and stone weirs. The delineation and inspection was performed on October 30, 2015 between 8AM and 2PM. Follow-up habitat assessments and mapping took place on November 11, November 18 and December 10, 2015.

Habitat assessments were conducted to inventory and evaluate important wildlife habitat features and to assist in the preparation and submission of the Application package. Wildlife habitat evaluations were performed through both direct site inspections and the review of any existing data to identify, characterize, and inventory important habitat features and indicators of wildlife usage. This section details those species that were directly observed, indicated through physical evidence (tracks, scat, etc.), and/or identified by unique signature traits (call). In addition, those species which could potentially utilize the assessed habitats given the presence of specific features have been identified.

The wetlands were delineated in accordance with the standards outlined in *Appendix 2* of the *Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act* (effective July 16, 2014). NRS field delineations consisted of identifying and classifying both soils and vegetation, which generally included examining soils for the presence of morphologic features indicative of hydric soils, and determining whether the existing plant community was dominated (≥50%) by hydrophytes.

Assessment also included examining USGS topographic maps for the depiction of perennial (i.e. blue-line) streams, water bodies and depressed areas. The Soil Survey of Rhode Island (Rector 1981) was examined for the presence of hydric soils and perennial waterways, as well as any hydrologic connection

to known public water supplies. NRS also consulted the State of Rhode Island 2012 303(D) List of Impaired Waters (DEM 2012) to determine water quality conditions of the subject waterway

Additionally, NRS used the online RIDEM Environmental Resource Map to review many of the Rhode Island Geographic Information System (RIGIS) data layers, including historical aerial imagery and those pertaining to natural heritage areas, critical habitat, flood hazard areas, surface water status, soils, surface water protection areas, and wetlands. Additional GIS data layers not available for viewing through the online viewers were obtained directly from RIGIS or DEEP for review. U. S. Fish & Wildlife Service (USFWS) National Wetlands Inventory Data (NWI) was also reviewed via the online data discovery tool known as "Wetlands Mapper" to help identify and classify the location of additional riparian wetlands along the River.

2.2 Report Authors and Qualifications

NRS personnel involved in the evaluation of the proposed project and preparation of this report and permit application include:

- Scott Rabideau, P.W.S., Principal
- Edward Avizinis, Wetland Biologist/Soil Scientist

NRS prepared the Biological Narrative and related sections to support this permit application to the DEM, and specifically conducted evaluations of wetland functions and values related to wildlife, recreation and aesthetics in accordance with Rule 10.02 (E) of the RIDEM Wetlands Regulations.

Fuss & O'Neill, Inc. personnel involved in the evaluation of the proposed project and preparation of this report and permit application include:

- Nils Wiberg, P.E., CFM, Project Manager
- Sean Arruda, P.E., CFM, Senior Civil Engineer
- Rachael Weiter, E.I.T., Water Resources Engineer

Fuss & O'Neill compiled and assimilated information and evaluations provided by NRS (as noted above) into this written narrative, and specifically conducted evaluations of wetlands functions and values related to flood protection, groundwater and surface water supplies, water quality, and soil erosion and sediment control in accordance with Rule 10.02 (E) of the DEM Wetlands Regulations.

Resumes of qualified professionals are provided in *Appendix C*.

2.3 Freshwater Wetlands

Wetland resource areas within the immediate vicinity of the Bradford Dam area were field delineated by NRS on October 30th, 2015. Delineated wetland features include portions of the Pawcatuck River, three (3) swamps, a forested wetland and an area subject to storm flowage (ASSF). All delineated wetlands and their corresponding regulatory setback wetlands are also depicted on the Existing Conditions Plan (Sheet CS-102) and the Construction Access and Resource Area Plan (Sheet CS-103) included within the Project Plans.

A description of those wetlands which were directly evaluated by NRS is provided below in their respective categories.

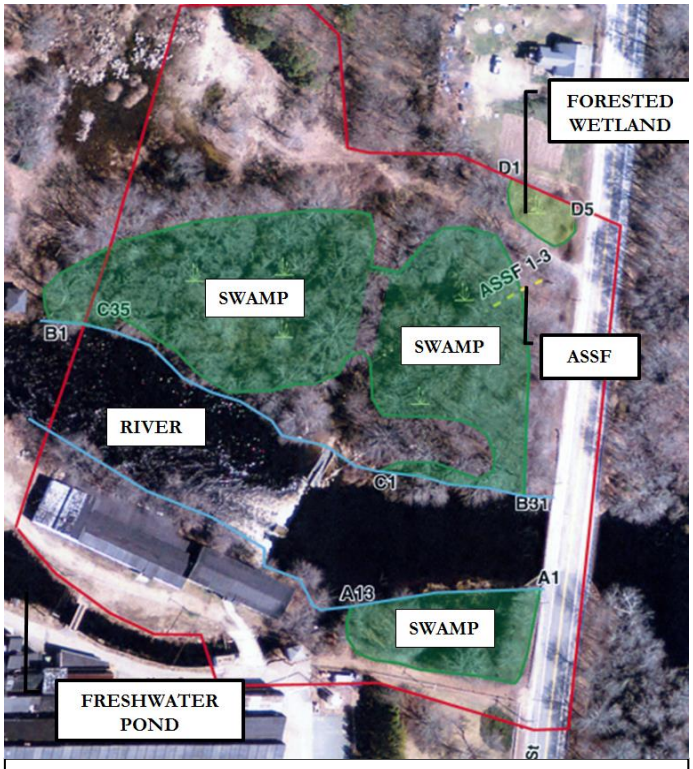

Illustration 5: Depiction of On-site Freshwater Wetlands

2.3.1 Riverine Wetlands

The Pawcatuck River is designated on the USGS Topographic Map as a blue-lined perennial stream, and is therefore considered by the DEM to be a river. The river is located within the Lower Pawcatuck River watershed, a watershed that is part of the largest river basin in Rhode Island. The Pawcatuck River and its tributaries drain most of southwestern Rhode Island into Little Narragansett Bay. Water depth varies within the portion of the river surrounding the dam. This variation ranges between two (2) and ten (10) feet, with an average width of approximately 130 linear feet. Streambed substrate varies with respect to location, but typically consists of cobble/gravel and sand with pockets of accumulated organics and/or muck.

The Pawcatuck River is associated with two (2) riparian swamps that abut the river to the east of the dam. These swamps can be found on both the north and south embankment of the river. The northern swamp (NRS A-series) is bisected by an existing historic path. This path maintains a north-south orientation and provides access to a pocket of non-jurisdictional upland that shall be used as a stockpile area during construction activities. This historic path shall be used for the wetland crossing as detailed in this report. Vegetation noted within these riparian swamps includes Red Maple (*Acer rubrum*), Winterberry (*Ilex verticillata*), Tussock Sedge (*Carex stricta*), Cinnamon Fern (*Osmundastrum cinnamomeum*), Southern Arrowwood (*Viburnum dentatum*), Sweet Pepperbush (*Clethra alnifolia*), Red Oak (*Quercus rubra*), Greenbrier (*Smilax glauca*), Highbush Blueberry (*Vaccinium corymbosum*), Sphagnum (*Sphagnum spp.*), Deertongue (*Dichanthelium clandestinum*) and Sensitive Fern (*Onoclea sensibilis*). Portions of the swamp maintain a mature canopy that fades along the historic path.

2.3.2 Palustrine Wetlands

There are also isolated palustrine wetlands outside of the freshwater resource areas that are contiguous with the Pawcatuck River. These features include an isolated forested wetland and an area subject to storm flowage (ASSF).

The palustrine forested wetland was generally found to support similar vegetative communities as that of the swamp. Similar vegetation noted by NRS included Red Maple (*Acer rubrum*) Cinnamon Fern (*Osmundastrum cinnamomeum*), and Highbush Blueberry (*Vaccinium corymbosum*), among others. The ASSF maintains an east-west flow as it passes into the northernmost swamp. This feature extends outward to the road, but does not exceed the limits of Route 91. The ASSF and the forested wetland likely receive surface water from the adjacent roadway and upland features.

2.3.3 Upland Habitat

There are multiple areas of upland throughout the project site, some of which is designated as regulatory setbacks afforded to the wetland features (the perimeter and riverbank wetlands). Notable upland features include Route 91, existing cart paths, commercial buildings and vegetated areas. Downstream of the dam, some forested upland areas are intermixed with residential and commercial development. Common vegetation observed within the upland areas includes Red Oak (*Quercus rubra*), Arrowwood (*Viburnum dentatum*), Sweet Pepperbush (*Clethra alnifolia*), Red Maple (*Acer rubrum*) and Greenbrier (*Smilax rotundifolia*).

2.4 Wildlife and Wildlife Habitat

This section addresses the wetland values and habitat qualities of the on-site features. In addition, NRS has also reviewed the upstream habitat brought to the engineer's attention by TNC. The following content of this report shall address these habitat concerns.

2.4.1 Wetland Characteristics

The information detailed in the preceding section of this narrative identifies the freshwater wetlands that occur on-site and which may be affected by the proposed dam removal and fish passage restoration project. NRS staff has completed a habitat assessment, which in turn was processed to evaluate the potentials to support various forms of wildlife.

2.4.2 Wildlife Indicators

Those species that were directly observed or identified by other indicators such as scat, tracks, trails, dens, and vocalizations during the NRS site visit are listed within the following table:

Table 3: Wildlife Species Directly Observed or Identified by NRS

Common Name	Scientific Name
Song Sparrow	*Melospiza melodia*

Nuthatch	*Sittidae*
White-tailed Deer	*Odocoileus virginianus*
Gray Squirrel	*Sciurus carolinensis*
Coyote	*Canis latrans*
Raccoon	*Procyon lotor*
Black-capped Chickadee	*Poecile atricapillus*

This list is limited due to the time of year the site visits occurred. Wildlife habitat which could be used by game or non-game species is present throughout the dam area. Wildlife habitats include the open water and bed of the river (fish, waterfowl, waders, shellfish, invertebrates), riverine aquatic bed/non-persistent emergent wetland (fish, waterfowl, invertebrates), vegetated and undercut embankments (passerines, mink, river otter, belted kingfisher, small mammals) and the various wetland and upland habitats. Throughout the wetland and upland areas, NRS staff noted a moderate amount of organic debris, leaf litter, water-soaked or rotten logs, overhanging branches emergent vegetation and dense vegetation. In addition, there were also a few distinct characteristics in the form of tree cavities, nest holes, rock crevices and stone walls. The following chart has been prepared by NRS to depict the potential species that may find the available habitat values suitable but were not directly observed at the time of the habitat assessment:

Table 4: Potential Wildlife Species Not Directly Observed or Identified by NRS

Common Name	Scientific Name
Great Blue Heron	*Ardea Herodias*
Turkey Vulture	*Cathartes aura*
Canada Goose	*Branta canadensis*
Mute Swan	*Cygnus olor*
Wood Duck	*Aix sponsa*
American Black Duck	*Anas rubripes*
Mallard	*Anas platyrhynchos*
Blue-winged Teal	*Anas discors*
Green-winged Teal	*Anas carolinensis*
Sharp-shinned hawk	*Accipiter striatusq*
Cooper's Hawk	*Accipiter cooperii*
Wild Turkey	*Meleagris gallapavo*
Mourning Dove	*Zenaida macroura*
Eastern Screech Owl	*Megascops asio*
Great Horned Owl	*Bubo virginianus*
North Saw-whet Owl	*Aegolius acadicus*
Common Nighthawk	*Chordeiles minor*
Whip-poor-will	*Caprimulgus vociferous*
Ruby-throated hummingbird	*Archilochus colubris*
Belted Kingfisher	*Megaceryle alcyon*
Hairy Woodpecker	*Leuconotopicus villosus*
Downy Woodpecker	*Picoides pubescens*

Common Name	Scientific Name
Red-bellied Woodpecker	*Melanerpes carolinus*
Northern Flicker	*Colaptes auratus*
Eastern Wood-Pewee	*Contopus virens*
Least Flycatcher	*Empidonax minimus*
Eastern Phoebe	*Sayornis phoebe*
Great Crested Flycatcher	*Myiarchus crinitus*
Eastern Kingbird	*Tyrannus tyrannus*
Red-eyed Vireo	*Vireo olivaceus*
Yellow-throated Vireo	*Vireo flavifrons*
Blue Jay	*Cyanocitta cristata*
Tree Swallow	*Tachycineta bicolor*
Tufted Titmouse	*Baeolophus bicolor*
Brown Creeper	*Certhia americana*
Carolina Wren	*Thryothorus ludovicianus*
House Wren	*Troglodytes aedon*
Veery	*Catharus fuscescens*
Hermit Thrush	*Catharus guttatus*
Wood Thrush	*Hylocichla mustelina*
American Robin	*Turdus migratorius*
Gray Catbird	*Dumetella carolinensis*
Northern Mockingbird	*Mimus polyglottos*
Cedar Waxwing	*Bombycilla cedrorum*
Yellow Warbler	*Setophaga petechial*
Yellow-rumped Warbler	*Setophaga coronate*
Pine Warbler	*Setophaga pinus*
American Redstart	*Setophaga ruticilla*
Common Yellowthroat	*Geothlypis trichas*
Eastern Towhee	*Pipilo erythrophthalmus*
American Tree Sparrow	*Spizella arborea*
Chipping Sparrow	*Spizella passerine*
Song Sparrow	*Melospiza melodia*
House Sparrow	*Passer domesticus*
Northern Cardinal	*Cardinalis cardinalis*
Baltimore Oriole	*Icterus galbula*
Purple Finch	*Haemorhous purpureus*
House Finch	*Haemorhous mexicanus*
American Goldfinch	*Spinus tristis*
Common Snapping Turtle	*Chelydra serpentine*
Eastern Painted Turtle	*Chrysemys picta*
Eastern Box Turtle	*Terrapene carolina carolina*
Northern Ringneck Snake	*Diadophis punctatus*
Black Rat Snake	*Pantherophis obsoletus*

Common Name	Scientific Name
Smooth Green Snake	*Opheodrys vernalis*
Eastern Ribbon Snake	*Thamnophis sauritus sauritus*
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*
Spotted Salamander	*Ambystoma maculatum*
Northern Redback Salamander	*Plethodon cinereus*
Eastern American Toad	*Anaxyrus americanus*
Gray Treefrog	*Hyla versicolor*
Northern Spring Peeper	*Pseudacris crucifer*
Bull Frog	*Lithobates catesbeianus*
Green Frog	*Rana clamitans*
Pickerel Frog	*Lithobates palustris*
Northern Leopard Frog	*Lithobates pipiens*
Wood Frog	*Lithobates sylvaticus*
Virginia Opossum	*Didelphis virginiana*
Common Water Shrew	*Sorex palustris*
Big Brown Bat	*Eptesicus fuscus*
Little Brown Myotis	*Myotis lucifugus*
Northern Myotis	*Myotis septentrionalis*
Eastern Cottontail	*Sylvilagus floridanus*
Southern Flying Squirrel	*Glaucomys volans*
Eastern Chipmunk	*Tamias striatus*
American Beaver	*Castor canadensis*
Woodland Jumping Mouse	*Napaeozapus insignis*
House Mouse	*Mus musculus*
Common Muskrat	*Ondatra zibethicus*
White-footed Mouse	*Peromyscus leucopus*
Gray Fox	*Urocyon cinereoargenteus*
Red Fox	*Vulpes vulpes*
Northern River Otter	*Lontra canadensis*
Fisher	*Martes pennant*
Striped Skunk	*Mephitis mephitis*

2.4.3 Wetland Values

The following section addresses the potential habitat values of the riverine, palustrine and upland areas.

2.4.3.1 Riverine Habitat

The evaluated section of the Pawcatuck River is located within the 11.36-mile long river segment in Rhode Island identified as Waterbody ID No. RI0008039R-18E. In addition, this portion of the river has been designated by the RIDEM as a Special Resource Protection Water (SRPW). This designation indicates high quality surface waters that include public water supplies and waterbodies having significant ecological or recreational uses. This portion of the River is designated as a SRPW for conservation,

critical habitat (rare and endangered species), and as a wild and scenic waterbody (DEM 2010a, 2014b). Moreover, the Pawcatuck River is listed on the State's 303(d) list for being impaired for Enterococcus.

The open water component of the Bradford Dam area of the Pawcatuck River provides habitat for a variety of cold-water fish species such as Brook Trout (*Salvelinus fontinalis*), and diadromous species such as River Herring (*Alosa* spp.) and American Shad (*Alosa sapidissima*) which are the primary focus of the current restoration efforts. The open water habitat also provides foraging opportunities for waterfowl (e.g., wood duck, mallard, Green-winged Teal (*Anas carolinensis*), Hooded Merganser (*Lophodytes cucullatus*), Ring-necked Duck (*Aythya collaris*), wading birds (e.g., Great Blue Heron (*Ardea herodias*), Green Heron (*Butorides virescens*), etc.), raptors (e.g., Osprey (*Pandion haliaetus*)), kingfishers, herpetiles (e.g., Northern Water Snake (*Nerodia sipedon*), Common Snapping Turtle (*Chelydra serpentina*), Painted Turtle (*Chrysemys picta picta*), Wood Turtle (*Glyptemys insculpta*), Green Frog (*Rana clamitans*), Pickerel Frog (*Rana palustris*), Red-spotted Newt (*Notophthalmus viridescens*), etc.), and mammals such as Northern River Otter (*Lontra canadensis*), American Beaver (*Castor canadensis*), Muskrat (*Ondatra zibethicus*), Star-nosed Mole (*Condylura cristata*), and various bats (e.g., Little Brown Myotis (*Myotis lucifugus*)), Silver-haired Bat (*Lasionycteris noctivagans*), Eastern Pipistrelle (*Pipistrellus subflavus*). The body of the Pawcatuck River also provides loafing/resting habitat for geese and other waterfowl.

Submergent and emergent vegetation within the River, including *Lemna* spp., Wild Celery, and non-persistent emergent species such as Pickerelweed and Bur-reed, are also attractive and important food sources for waterfowl, wading birds, and muskrat. Emergent vegetation also provides habitat for various life stages of numerous invertebrates.

The steep embankments along the channel are generally densely vegetated and/or are undercut with exposed root masses. This provides suitable cover, travel, foraging, and denning habitat for small mammals. Dens, which were likely created by muskrat and/or beaver, were exposed at the time of evaluation due to a low water level.

2.4.3.2 Palustrine Habitats

The forested wetland is similar to the swamp in terms of plant composition, structural diversity and water regime. This isolated wetland pocket maintains an overstory created by mature trees and moderate to dense shrub and herbaceous layers that provide cover, nesting, and resting habitat for passerines, small mammals and herpetiles. Microtopography is typically flat to irregular, and many of these areas are located within areas subject to flooding by the River. Important habitat features that are present within the majority of these areas include abundant food sources such as seeds, berries, mast and browse; dense shrub and herbaceous vegetation; large diameter trees; root cavities; coarse woody debris; leaf litter; and dead standing trees for cavities and perches.

Rocks, crevices, logs and tree roots are also present under and at the water's surface along the waterfront edges of the riparian wetlands. These features provide suitable habitat for turtles, snakes, frogs, wading birds, wood duck, mink, and raccoon.

2.4.3.3 Upland Habitats

All of these areas encompass a variety of habitat types and land uses, including deciduous forest, residential and commercial properties and an existing clearing. Although vegetative composition and structural diversity vary with respect to the location and/or type of upland community, the majority of upland habitats along the span of the Pawcatuck River consist of mature deciduous forest with a dense overstory canopy and a sparse to moderately dense understory. Areas within the vicinity of the residential and commercial land uses have less structural diversity and more even-aged vegetation. Some of these areas have a dense understory.

Most upland habitats are dominated by oaks (*Quercus* spp.) and maples (*Acer* spp.). These forested areas may provide bedding areas for White-tailed Deer (*Odocoileus virginianus*), roost sites for wild turkey and other game birds, as well as travel sites, cover, nesting/denning sites, and food sources for a variety of mammals (e.g., Coyote (*Canis latrans*), Red Fox (*Vulpes vulpes*)), birds, and herpetiles. Dense leaf litter and coarse woody debris, as well as root cavities and other crevices, provide escape and travel cover, foraging habitat, reeding/nesting sites and resting areas for small mammals as well as many herpetiles, including snakes and amphibians which utilize uplands for part of their life cycle (e.g., wood frog, marbled salamander, spotted salamander, American toad, etc.).

These areas are also suitable for use by semi-terrestrial species such as the Eastern Box Turtle (*Terrapene carolina carolina*) and terrestrial species like the Red-backed Salamander (*Plethodon cinereus*). Semi-aquatic species such as the common snapping turtle, as well as other species that prefer sandy soils (e.g., Fowler's toad (*Anaxyrus fowleri*), are also likely to utilize many of the subject upland habitats for activities such as nesting/egg laying, aestivation and foraging.

2.4.4 Potential Effects on Wetland and Wildlife Habitat

Potential short-term impacts to wildlife associated with this restoration project primarily include those resulting from the construction process. Such disturbances are expected to include increased noise, human presence, substrate disturbances/turbidity occurring from in-water work, vegetative disturbances, temporary fill associated with the access road, and the installation of channel bank stabilization. The noted activities could temporarily displace resident and transient wildlife that currently utilize the affected habitats or reduce the availability/attractiveness of habitats for some species, particularly wildlife that are sensitive to disturbances or have specific habitat requirements (e.g., fish). During construction, displaced species are expected to relocate and/or utilize adjacent habitats given the continuity of the project area with similar habitat types. Short-term impacts to wildlife are expected to cease upon completion of the project and/or restoration and stabilization of disturbed areas, and wildlife usage is expected to return to at least pre-project levels.

Although the removal of the dam will result in some alterations to wildlife and wildlife habitat, the net benefits of the proposed habitat restoration project to the target species and river system as a whole far outweigh any such impacts. The construction of the rock ramp with resting pools and stone weirs will help to reintroduce additional wildlife species such as the American Shad (*Alosa sapidissima*) to this area and other upstream habitats. By maintaining a similar water level to that of predevelopment levels, the

project shall also maintain critical upstream riverine habitats that have colonized since the construction of the dam in the 1700s.

This project will provide river continuity and restore habitat for numerous aquatic and benthic flora and fauna, which have been altered since construction of the first dam along the river in the 1700's. While significant benefits will result from this project, alterations will occur as a result of direct impacts from construction activities and indirect changes resulting from altered hydrology within the river system. These changes are described in further detail in the following sections.

2.4.5 Upstream Vegetative Response

The Nature Conservancy has completed a North Atlantic Coast Ecoregional Assessment that has identified a number of rare or endangered species that may be impacted by the drop in water level to result from the dam. Approximately 3,500 feet upstream of the dam, there is a wetland complex that is considered a coastal plain quagmire (state critically impaired and globally vulnerable), coastal plain floodplain swamp (state critically imperiled), acidic level fen (state imperiled), and acid level bog (state vulnerable). These habitat areas play a key role in supporting known species of state-endangered plants, including Podgrass (*Scheuchzeria palustris*), Swamp Pink (*Arethusa bulbosa*), and Horned Rush (*Rhynchospora inundata*); as well as a state threatened plant: Two-flowered Bladderwort (*Utricularia biflora*); and many state concern plants: Dwarf Huckleberry (*Gaylussacia dumosa*), Goat's Rue (*Tephrosia virginiana*), Sundial Lupine (*Lupinus perennis*), Zizgzag Bladderwort (*Utricularia subulata*), Spike Rush (*Eleocharis equisetoides*) and Grass-pink (*Calopogon tuberosus*).

The applicant has mitigated this hazard by maintaining a rock ramp fishway with an upstream grade control structure in the project design, rather than the complete removal of the dam and converting the area back to its natural grade. The current proposal shall maintain the upstream water levels similar to that of predevelopment levels while still allowing for the passage of fish into such areas.

3. Recreation and Aesthetics

In its current form, the river upstream and downstream of the dam provides much in the way of recreational and aesthetic functions and values. Such values include wildlife observation, bird watching, swimming, canoeing and fishing. Public access to the dam is restricted by chain link safety/security fencing around the BPL Realty property. This project will not cause a significant reduction to these active or passive recreational values. The dam shall be replaced with a rock ramp fishway and grade control structure, allowing water to maintain similar levels up and downstream of the project. The project also includes the installation of a non-designated portage route to the north of the rock ramp that will enhance the public's ability to safety hand-carry canoes/kayaks adjacent to the rock ramp on river-right. Restoration of flows to the river channel via the rock ramp will significantly improve safety by removing the hazard of the current 4-6 foot drop over the dam's spillway, thus reducing the need for boaters to portage at the site, while also improving fishing and other recreational opportunities along the River by promoting upstream and downstream fish passage and spawning at upstream habitats, significantly reducing fragmentation of habitat for other resident recreational sport fish, and improving boating accessibility to portions of the river downstream of the dam.

As noted above, the design of the rock ramp has been developed to minimize any reduction of upriver water levels and maintain sufficient flow depths for fish passage, which will also facilitate recreational boater use. Each of the weirs proposed within the rock ramp fishway will contain a 10-foot wide low-level notch that will pass a minimum of 30-inches of flow under low-flow conditions during the fish passage season. Hydraulic drops across each weir have also been limited to 10 inches or less under all flow conditions. Additionally, the rock ramp will be constructed of sub-angular and rounded stone to create a structure resembling a natural riffle in an unaltered river channel, as opposed to structural fish passage techniques/alternatives where baffles, vertical slot, and other concrete pool-and-weir structures are required. Any man-made materials and structures proposed in the design (i.e., the upstream steel sheeting cutoff) will be covered by natural stone armor. As a result, the project will result in a more natural, aesthetic site, while improving recreational opportunities.

The Project will also limit flow into the former Millrace via the installation of an earthen barrier with a conduit and sluice gate that will allow the property owner to control flow into the millrace and the man-made waterbodies downstream. As a result, boaters will be prevented from entering the millrace, which is on private property and currently presents a potential safety hazard to boaters as well as a security and liability concern to BPF Realty, LLC. This barrier structure is designed with vegetated soil-filled stone armor to withstand potential scour from overtopping flows. Man-made materials (i.e., geotextile fabrics) will be covered below the stone armor and will not be visible.

During construction, a boater safety boom will be installed upstream of the grade control structure and temporary cofferdam to be constructed upgradient of the project site, with signage directing boaters to a designated portage take-out location on river-right, upstream of the temporary diversion channel inlet. Portaging boaters will be directed by barricades/signage along the diversion channel to an optional put-in location downstream of the diversion channel outlet, where they can put-in. Similarly, boaters paddling upstream from below the project site will be directed by signage to a take-out location downstream of the diversion channel outlet, where they can portage on the designated footpath along the diversion channel, and put in upstream of the diversion channel inlet, to continue paddling upriver.

The project will not adversely impact the existing gated access ways to the dam, which will be temporarily used for the project to support access to and from the construction and temporary staging/storage/stockpile area, and will be restored to existing conditions upon the completion of this project.

4. Flood Protection and Fish Passage

For purposes of this report, the project limits include areas where river water surface elevations will be altered as a result of dam removal. Based on the results of hydraulic modeling, the projects limits for this project were established as described below:

- from a point approximately 823 feet (or 0.16 miles) downstream of the Bradford Dam referred to herein as "the downstream limit of study;"
- to a point approximately 3,635 feet downstream of the King's Factor Road Bridge (or 6.46 miles upstream of the Bradford Dam) referred to herein as "the upstream limit of study."

These are the limits where upstream and downstream convergence is achieved between the pre- and post-condition hydraulic models under all flow conditions.

The removal of the Bradford Dam and its replacement with a rock ramp fishway and grade control structure (and associated in-river channel improvements) has been evaluated using the Hydrologic Engineering Center-River Analysis System (HEC-RAS) modeling software. HEC-RAS is a software program that was developed by the Hydraulic Engineering Center (HEC) which is a division of the U.S. Army Corps of Engineers (ACOE). HEC-RAS allows one to perform one-dimensional steady and unsteady river or open-channel hydraulic calculations. HEC-RAS is capable of modeling water surface profiles under subcritical, supercritical, and mixed-flow conditions. This program was used to evaluate and predict water surface elevation and flow velocity changes caused by replacing the Bradford Dam structure with a rock ramp fishway and grade control structure and to modify the geometric design of the rock ramp fishway to meet fish passage design critieria for the target species.

In order to assess and quantify fish passage suitability, ecological alterations, and flood protection benefits associated with each dam removal alternative, pre- and post-dam removal hydraulic models were developed using HEC-RAS. The anticipated impacts associated with the removal of the Dam have been assessed at three primary hydrologic levels; (1) selected flood intervals including the 100-year recurrence interval flood event; (2) upstream fish migration flow conditions (i.e. during minimum, normal, and maximum operating conditions); and (3) the existing August/September water level which represents base flow conditions.

4.1 Watershed Drainage Characteristics and Flood Flows

The Pawcatuck River watershed was glacially formed and encompasses a total area of approximately 317 square miles; 260 square miles in Rhode Island and 57 square miles in Connecticut. This watershed is the largest watershed in Rhode Island draining nearly one third of the state. The Usquepaug, Wood, and Ashaway Rivers are the major tributaries of the Pawcatuck.

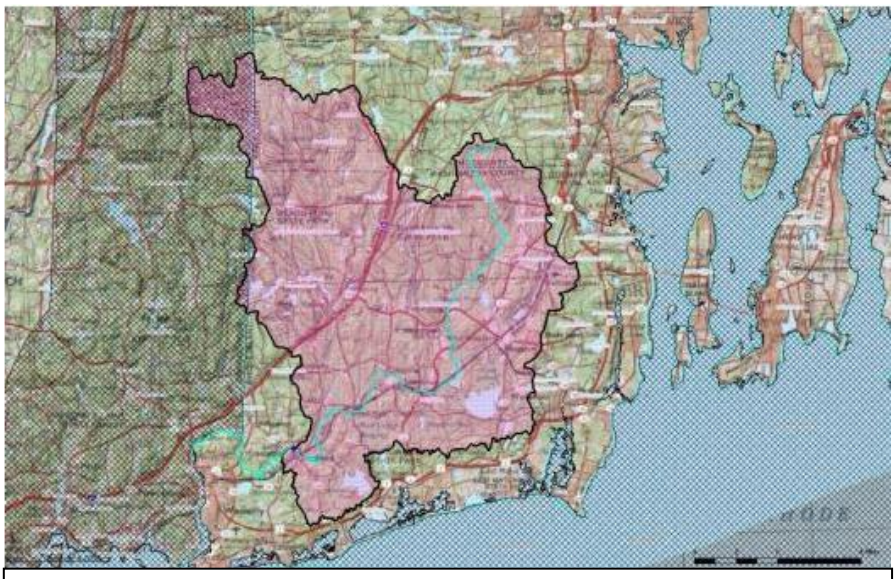

Illustration 6: Drainage Area at Bradford Dam (218 sq. mi.)

This freshwater drainage basin runs through rural uplands, woodlands, forests, and small towns that were once thriving mill villages. While scattered industries can be found along the River, large industrial

complexes are somewhat isolated from its banks. In the estuary (the saltwater portion of the watershed), rural land use gives way to the urban center of Westerly, Rhode Island.

The upper and middle portions of the basin are characterized by gently rolling hills interspersed with wetlands and ponds. The River meanders approximately 31 miles through rural areas in Rhode Island before entering a more urban setting in the Westerly-Pawcatuck area. The drainage area for the Dam site is approximately 218 square miles as determined using USGS StreamStats, 2016. The delineation of the watershed is reflected in *Illustration 6*. The Dam is located approximately 17.5 miles upstream from the mouth of the Pawcatuck River.

In response to the historic March 2010 flooding that was experienced in Rhode Island, USGS (in cooperation with FEMA) conducted a study to document the magnitude of flood flows over a range of flood events at stream gages in Rhode Island and to update statewide regional equations for estimating flood flows at ungaged locations. The results of this study were published in *Scientific Investigations Report 2012-5109, Version 1.2 (March 2013)*. The document not only provides updated statewide regional equations for estimating flood flows at ungagged stream locations, but presents updated estimates of flood flows at USGS stream gages for the 5-, 10-, 25-, 50-, 100-, 200-, and 500-year return interval floods. The following table (obtained from the report) reflects flood flows that were estimated at USGS Gage 01118500 in Westerly:

Table 5:
USGS Approximated Flood Flows at USGS Gage 01118500 in Westerly, RI

Annual exceedance probability (percent)	At-site		Regional regression		Weighted		Percent difference at site and weighted flow
	Flow (ft^3/s)	Variance	Flow (ft^3/s)	Variance	Flow (ft^3/s)	Variance	
Rhode Island streamgages—Continued							
Pawcatuck River at Westerly, RI (01118500)							
20	3,300	0.001	3,300	0.014	3,300	0.001	0.0
10	4,080	0.001	4,190	0.013	4,090	0.001	0.2
4	5,230	0.003	5,510	0.011	5,290	0.002	1.1
2	6,220	0.004	6,540	0.011	6,320	0.003	1.6
1	7,340	0.006	7,690	0.011	7,480	0.004	1.9
0.5	8,610	0.008	8,760	0.013	8,690	0.005	0.9
0.2	10,600	0.012	10,400	0.016	10,500	0.007	-0.9

The HEC-RAS model provided to Fuss & O'Neill by USGS utilized this updated flow information at selected locations throughout the River. However, USGS did not specify flows within a 2.9-mile stretch of the River in the vicinity of the Bradford Dam. Since flows at Bradford Dam and throughout the section of the River immediately upstream of the Dam were required in order to design the rock ramp fishway and to assess impacts to base condition and flood water surface elevations as a result of the project, Fuss & O'Neill utilized upstream watershed areas obtained from StreamStats to compute flows in the vicinity of the Project Site. Flows at selected river cross sections within this section of the River, up to King's Factory Road Bridge (just upstream of the limit of study), were then computed accordingly using the updated regional regression equation published in *Scientific Investigations Report 2012-5109, Version 1.2 (March 2013)* based on the drainage area sizes at these cross sections in respect to the drainage area size at the USGS gage station. In summary, the following flood flows were used to supplement flows provided by USGS at the Bradford Dam and upstream limit of analysis:

Table 6: Approximate Flows Conveyed By Pawcatuck River at the Bradford Dam During Flood Events (based on Drainage Area Ratio)

Flood Flow Event Recurrence Interval	Flow Rate at the Westerly Gage Station 295 Sq. Mi. Drainage Area	Flow Rate at Bradford Dam - 218 Sq. Mi. Drainage Area (Ratio = 0.74)	Flow Rate D/S of Poquiant Brook Confluence – 215 Sq. Mi. Drainage Area (Ratio=0.73)	Flow Rate at Burdickville Dam – 204 Sq. Mi. Drainage Area (Ratio=0.69)	Flow Rate D/S of Wood River Confluence – 203 Sq. Mi. Drainage Area (Ratio=0.69)	Flow Rate U/S of Wood River Confluence – 114 Sq. Mi. Drainage Area (Ratio=0.39)	Flow Rate U/S of Kings Factory Road Bridge – 107 Sq. Mi. Drainage Area (Ratio=0.36)
1-Year	1,265 cfs	935 cfs	922 cfs	874 cfs	870 cfs	489 cfs	459 cfs
2-Year	1,854 cfs	1,726 cfs	1,701 cfs	1,614 cfs	1,607 cfs	902 cfs	847 cfs
10-Year	4,090 cfs	3,025 cfs	2,980 cfs	2,830 cfs	2,815 cfs	1,580 cfs	1,480 cfs
25-Year	5,290 cfs	3,910 cfs	3,855 cfs	3,655 cfs	3,640 cfs	2,045 cfs	1,920 cfs
50-Year	6,320 cfs	4,670 cfs	4,605 cfs	4,370 cfs	4,350 cfs	2,440 cfs	2,290 cfs
100-Year	7,480 cfs	5,530 cfs	5,450 cfs	5,170 cfs	5,150 cfs	2,890 cfs	2,710 cfs
500-Year	10,500 cfs	7,760 cfs	7,650 cfs	7,260 cfs	7,225 cfs	4,060 cfs	3,810 cfs

It must be noted that the updated flood flows used in this analysis and to assess modifications to upstream and downstream water levels as a result of the removal of the Dam and proposed in-river channel improvements are greater than corresponding flood flows published in the current FEMA Flood Insurance Study (FIS) for Washington County dated October 16, 2013. This is expected due to increased urbanization within the watershed and the increased frequency in significant rainfall events as a result of climate change. The following table provides peak flow values included within the FIS for the 10-, 50-, 100-, and 500-year return interval floods for comparison purposes only.

Table 7: Approximate Flows Conveyed By Pawcatuck River at the Bradford Dam During Flood Events (per Current FEMA FIS)

Flood Flow Event Recurrence Interval	Flow Rate at the Westerly Gage Station 295 Sq. Mi. Drainage Area	Flow Rate at Bradford Dam and D/S of Poquiant Brook	Flow Rate at Burdickville Dam and D/S of Wood River Confluence	Flow Rate U/S of Wood River Confluence	Flow Rate U/S of Kings Factory Road Bridge – 107 Sq. Mi. Drainage Area (Ratio=0.36)
10-Year	3,400 cfs	2,450 cfs	2,350 cfs	1,250 cfs	1,100 cfs
50-Year	4,900 cfs	3,400 cfs	3,250 cfs	1,800 cfs	1,550 cfs
100-Year	5,700 cfs	3,900 cfs	3,700 cfs	2,050 cfs	1,750 cfs
500-Year	7,900 cfs	5,100 cfs	4,900 cfs	2,700 cfs	2,350 cfs

4.2 Upstream Fish Migration Flows

The USGS study did not provide information for fish passage flow rates expected to occur during the upstream migration period. The operating flow range for fish passage refers to the range of stream flows in which fish passage is known to naturally occur. Prediction of this flow range is necessary to determine whether an existing waterway or a designed waterway will be passable by fish.

The operating flow range for the Dam was determined through analysis of flow data recorded at the Westerly stream gage. The Westerly stream gage (USGS 01118500) is located approximately 10.5 miles downstream from Bradford Dam. Mean daily flows recorded at this gage station for the past thirty years (from 1985 through 2015) during the upstream fish migration period/season were utilized. The upstream migration period for this region (particularly for river herring and American shad) was considered to range from March 15th through June 15th based on recommendations provided by RIDEM Division of Fish & Wildlife staff and USFWS staff.

USFWS criteria requires safe, timely and effective passage for migrating fish during all flows between the 95% and 5% non-exceedance probability values during this period. The probability of exceedance describes the likelihood of a specified flow rate being exceeded during the upstream migration period. In order to compute these non-exceedance flows at the Bradford Dam, non-exceedance flows computed at the Westerly gage station were scaled-down down by a factor of 0.74 based on the project site's drainage area of approximately 218 square miles in respect to the 295 square mile drainage area at Westerly gage station. This methodology is referred to as the Drainage Area Ratio Method.

At the Bradford Dam, adequate fish passage is required for all flows was computed to range between 221 cfs and 1,434 cfs. The following table and illustration reflect the minimum (5% non-exceedance), normal (50% non-exceedance), and maximum (95% non-exceedance) operating flows used in the analysis to assess fish passage at the Bradford Dam:

Table 8:
5%, 50%, and 95% Non-Exceedance Flows Conveyed By Pawcatuck River at Westerly Gage Station and Bradford Dam during March 15 – June 15 Upstream Fish Passage Migration Season

Flow Event	Flow Rate (cfs) at USGS Westerly Gage Station (295 Sq. Mi. Drainage Area)	Adjusted Flow Rate (cfs) at Bradford Dam (218 Sq. Mi. Drainage Area)
Min. Operating Conditions (5% Non-Exceedance)	299 cfs	221 cfs
Normal Operating Conditions (50% Non-Exceedance)	719 cfs	531 cfs
Max. Operating Conditions (95% Non-Exceedance)	1,940 cfs	1434 cfs

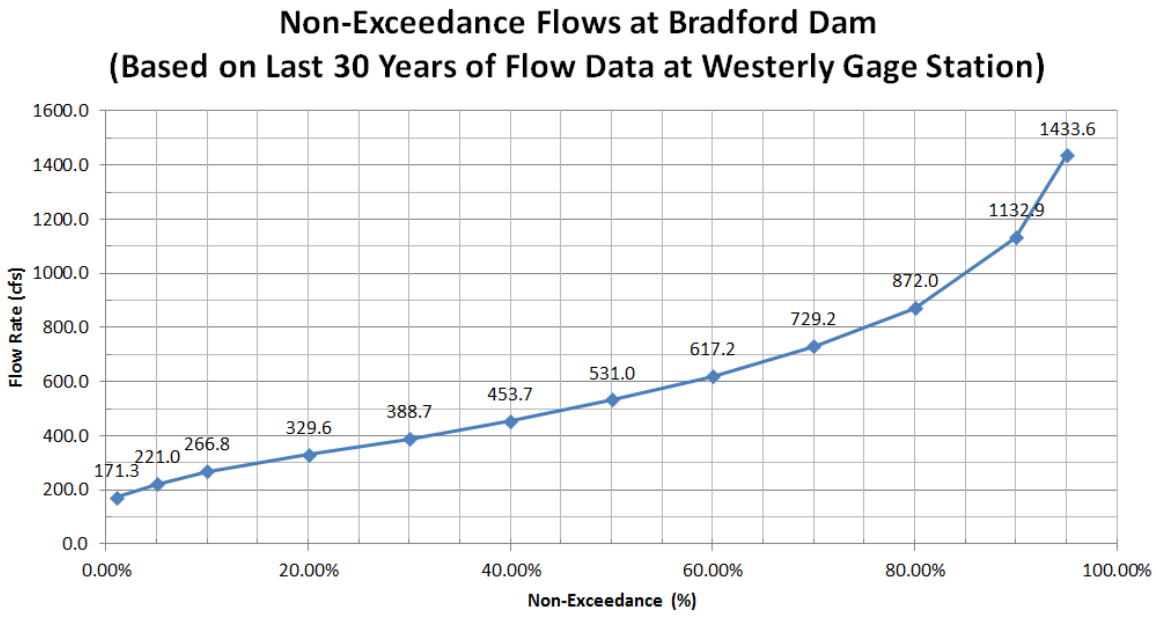

Illustration 7: Non-Exceedance Flows at Bradford Dam

4.2.1 Fish Passage Suitability Criteria

As identified in USFWS's *Draft July 2014 Evaluation of Fish Passage Efficiency Report*), the anadromous species (species that migrate from sea to freshwater to spawn) of major concern (or target species) on the River include the American shad, alewife, and blueback herring. Each has specific upstream migratory periods. In Rhode Island, river herring tend to perform their upstream migratory activities between March 1st and June 1st, peaking in April. Shad display their migratory period between April 1st and July 1st, typically peaking in May. Therefore, the full breadth of upstream migration for the specified target species is March 1st to July 1st. However, the upstream migration period conservatively recommended for analysis for this Project is March 15th through June 15th based on recommendations from RIDEM Division of Fish and Wildlife staff and USFWS staff.

In assessing potential barriers to migratory fish passage (subsequent to Dam removal and rock ramp fishway construction), criteria documented within USFWS's *Draft July 2014 Evaluation of Fish Passage Efficiency Report* as well as criteria developed by NOAA, USFWS, USGS and other federal agencies pertaining to the swimming speeds of the target species were utilized. The following table provides specific characteristics for each of the target species of primary concern in addition to American eel.

Table 9: Target Fish Species Characteristics for Fishway Design

	Alewife	Blueback herring	American eel	American shad
Classification	Anadromous	Anadromous	Catadromous	Anadromous
Upstream Migration	March 1- June 1 (Peak in April)	March 1 - June 1 (Peak in Late April to Early May)	March 15 -Sept. 30 (Peak in May to Early June)	April 1 - July 1 (Peak in May)
Downstream Migration	June - Nov.	June - Nov.	Late Summer - Fall	September-October
Min. Depth for Adults	≥ 15"	≥ 12"	≥6" (for eels less than 150 mm TL) ≥12" (for eels greater than 150mm TL)	≥ 30"
Swimming Speed (Adults)				
Cruising Speed (ft/s)	2.8±	2.8±	1.0±	2.8±
Burst Speed (ft/s)	5.5±	6.0±	4.6 (for eels less than 150 mm TL) 4.9 (for eels greater than 150mm TL)	7.0±

	Alewife	Blueback herring	American eel	American shad
Pool and Weir Characteristics (Adults)				
Min. Pool/Channel Width (ft)	5.0	5.0	3.0 (for eels less than 150 mm TL) 6.0 (for eels greater than 150mm TL)	20.0
Min. Pool/Channel Depth (ft)	2.0	2.0	1.0 (for eels less than 150 mm TL) 2.0 (for eels greater than 150mm TL)	4.0
Min. Pool/Channel Length (ft)	10.0	10.0	5.0 (for eels less than 150 mm TL) 10.0 (for eels greater than 150mm TL)	30.0
Min. Weir Opening Width (ft)	2.50	2.00	1.00 (for eels less than 150 mm TL) 2.00 (for eels greater than 150mm TL)	4.25
Min. Weir Opening Depth (ft)	1.25	1.00	0.50 (for eels less than 150 mm TL) 1.25 (for eels greater than 150mm TL)	2.50
Max. Fishway Channel Slope	1:20	1:20	1:20	1:30
Max. Weir Opening Water Velocity (ft/s)	6.00	6.00	0.75	7.00

Notes:
1. "Cruising speed" is speed that can be maintained by a particular fish species for greater than 200 minutes (essentially, indefinitely).
2. Burst speed is expected to be only maintained by a particular fish species for up to 20 seconds based on fatigue time in respirometer or flume experiments. This swimming mode is typically used when attempting to pass a river flow drop or weir opening where velocities are highest.

Fuss & O'Neill's post-conditions hydraulic modeling was used in the design of the rock ramp fishway to confirm that adequate flow depths and velocities through the rock ramp fishway were achieved.

4.3 Base Condition Flows

Due to potential alterations that the removal of the Dam may have on water surface levels within proximate and upstream wetlands, the median mean daily August-September flow (referred to herein as the base flow) was evaluated. The ecology of wetland systems bordering the river may be governed by water surface elevations during these base flow conditions; and as a result, it is important to evaluate changes in water surface elevations during these seasonal low-flow periods in order to fully assess impacts that dam removal will have on these wetland communities (as further discussed in *Section 5* of this report).

The base condition flow used in this analysis represents the median mean daily August-September flow as determined from flow data obtained from the USGS gauge station at the Westerly stream gage (USGS 01118500). Using the average of the median mean daily August-September flows (over the last 30 years

only) the base-condition flow was calculated to be approximately 232 cfs at the gage station. To relate this flow to the project site which is approximately 10.5 miles upstream of the gage station, this flow was scaled-down using the Drainage Area Ratio Method described in *Section 4.1*. As a result, the mean daily August-September flow was estimated to be approximately 172 cfs at the Bradford Dam.

4.4 Wetland Flood Protection Values and Drainage Characteristics

The Dam impounds water approximately 5.0 miles upstream under base flow conditions. As a result, flood protection functions and values provided by a majority of wetlands upstream of the Dam have already been influenced and impacted by the construction of the Dam.

Since the project does not propose alterations to the hydrologic characteristics the Pawcatuck River nor does it propose alterations that will result in increases in flood elevations upstream or downstream of the rock ramp fishway, the ability of these wetlands to temporarily store or meter out flood waters during storm events will not be adversely impacted as a result of the project. In fact, the project will result in minor reductions in dry- and wet-weather water surface elevations upstream of the dam which will potentially enhance the ability of upstream wetlands to provide flood protection.

The rock ramp was also designed to achieve an approximate 120 to 130 feet width under low-flow conditions to better mimic the natural width of the River in this location (prior to being constricted by the construction of the Dam and adjoining Denil fish ladder). This widening, within the project's limit of disturbance, will result in a net excavation of approximately 2,220 cubic yards of material. This will enhance the River's ability to meter out flood flows and the ability of the adjacent swamp areas to provide flood storage.

4.5 Analysis of Anticipated Impacts

Since the project will not result in modifications to the amount of runoff discharging to the River or adjacent freshwater wetlands, there will not be an increase in peak flow rates discharged to the River upstream, downstream, or through the project site.

The removal of the Dam and construction of the rock ramp fishway (with upstream grade control structure) has been designed to provide adequate fish passage for migratory fish and resident species while also avoiding increases to river flood elevations (i.e. the 100-year flood) and significant water surface elevation reductions upstream of the Dam during base flow conditions that could result in ecological impacts to sensitive upstream wetland resources. In order to achieve these goals, the following design strategies were proposed:

- <u>The majority of the rock ramp was proposed upstream of the Dam (within the headpond).</u> Siting the rock ramp fishway upstream of the Dam allows for the gradual transition between headwaters and tailwaters to occur prior to reaching the downstream side of the Dam. This avoids increases in flood elevations that would normally occur with a rock ramp fishway if it were proposed downstream of the Dam. Proposing a rock ramp downstream of the Dam normally results in the raising of the channel bottom immediately downstream of the Dam

forcing the gradual transition between headwaters and tailwaters of the River to occur in a location where there was previously an immediate drop in water surface elevations. Note that two of the eight rock weirs associated with the rock ramp fishway proposed downstream of the former Dam are submerged due to the backwatering effect the Potter Hill Dam has on tailwater elevations experienced downstream of the Bradford Dam during significant flood events. Excavation proposed downstream of the rock ramp will create 4-foot deep pools in between the weirs for fish passage and energy dissipation purposes as well as contribute to the project's avoidance of increases in tailwater flood elevations immediately downstream of the Dam.

- The rock ramp fishway was designed with an upstream grade control structure that limited reductions in upstream base condition water levels to six inches or less. The Dam impounds flow for a distance of approximately 5.0 miles upstream. Within this stretch of the River lie several natural resource areas including a natural heritage area, the Grills Preserve, the Wood State Hunting and Fish Area, and the Phantom Bog.

  Phantom Bog is a shallow, peaty bog and pond complex with floating sphagnum moss islands that is located along the north shore of the Pawcatuck River just upstream of the River's confluence with the Poquiant Brook. It is the site of several rare species and communities of special emphasis or concern in the region. These include Barrens buckmoth (*Hemileuca maia*), Barrens bluet damselfly (*Enallagma recurvatum*), inundated horned-rush (*Rhynchospora inundata*), and Torrey's beak-rush (*Rhynchospora torreyana*). The bog is surrounded by high-quality examples of pitch pine (*Pinus rigida*) - scrub oak (*Quercus ilicifolia*) barrens.

  The upstream grade control structure was designed with a top elevation that was approximately equivalent to the lowest invert of the Dam's spillway. This would keep upstream base condition flow elevations at roughly the same elevation as the existing Dam. The upstream grade control structure was then designed with a 10-foot wide low-level notch to allow fish and recreational boaters an adequate means of passage. The invert of the 10-foot wide low-level notch was set approximately 30 inches below the top of the structure in accordance with latest NOAA recommendations for fish passage notches. Two upper-level 5-foot wide notches were also proposed within the grade control structure to provide additional means for fish passage under varying flow conditions. The incorporation of these notches resulted in minor reductions in upstream water surface elevations during base conditions. However, these notches were designed to limit these reductions to six inches or less to avoid ecological impacts to upstream wetland resources.

- The effective width of the River and rock ramp fishway was increased to match the natural width of the River. The natural width of the River is currently constricted by the Dam as the lower portion of the Dam's spillway (with an invert elevation varying between 32.5 to 32.6 feet) is approximately 73.1 feet wide. Since the natural width of the River in this location varies between 120 feet and 130 feet, the width of the rock ramp was designed to match the natural channel width under base flow conditions. This increase in channel width results in wider upstream grade control structure that, in turn, allows more flow to pass over it during base flow and flood conditions at a lower elevation (as compared to the existing Dam). This also contributes to minor reductions in upstream base flow conditions water surface elevations as well as minor reductions in upstream flood elevations.

- The rock ramp fishway was designed to adhere to NOAA's latest recommendations for nature-like fishways. Since the primary goal of this project is to restore river continuity for migratory fish, the weirs and pools associated with the rock ramp was designed in accordance with NOAA's latest recommendations (10-foot wide low-level notch with a 2.5-foot minimum weir opening depth, weirs spaced at 30-foot minimum intervals and pools between weirs designed with 4-foot minimum pool depths at minimum operating flow conditions). Hydraulic drops across each weir were limited to approximately 9 to 10 inches resulting in an average fishway channel longitudinal slope of between 2.5% to 2.7% (which is below the 3.0% recommended maximum fishway channel slope). Maximum flow velocities in the pools were limited to less than 2.8 feet per second which is considered to be the cruising speed of the target species.

As summarized in subsections below, the results of our analyses indicate that the construction of a rock ramp with a grade control structure will provide significantly improved fish passage at the Dam while minimizing the reduction of upstream base condition water surface elevations and providing marginal reductions in extreme flood water surface elevations throughout, upstream, and downstream of the nature-like fishway.

In order to assess these anticipated impacts to water surface elevations within the River and adjacent wetlands as a result of dam removal and installation of the rock ramp fishway, HEC-RAS analyses of the River were performed under pre- and post-project conditions.

4.5.1 Hydraulic Model

Fuss & O'Neill has obtained and reviewed the most recent HEC-RAS model of the river system, which has been developed by the U.S. Geologic Survey (USGS) as part of FEMA's ongoing map modernization and Risk Mapping, Assessment and Planning (RiskMAP) study of the Pawcatuck River system. This model has been provided to Fuss & O'Neill by technical staff at USGS for use on this project, under the condition that Fuss & O'Neill obtain permission before releasing this model to any other persons. This model represents a more detailed model of the river system as compared to FEMA's current model as it incorporates several more LiDAR and field surveyed cross-sections throughout the river reach. More detail pertaining to the develop of this model is documented within USGS's *Simulated and Observed 2010 Floodwater Elevations in the Pawcatuck and Wood Rivers, Scientific Investigations Report 2013-5193*.

USGS's model initially included 362 cross-sections between Worden's Pond (the initial upstream limit of analysis) and a point approximately 2.15 miles downstream of the White Rock Dam (the downstream limit of analysis). The model also included 26 bridges and 5 in-line structures (or dams).

4.5.2 Modified Base (Pre-Conditions) Hydraulic Model

Since alterations associated with the Dam removal and replacement with a rock ramp fishway will extend up to the King's Factory Road Bridge (as the river channel has a steeper channel bottom slope in this area), Fuss & O'Neill modified the upstream limit of the hydraulic model to occur approximately 900 feet upstream of the King's Factory Road Bridge by eliminating all cross sections upstream of this point. As a result, this cross section (RS10545.1) is the modified upstream limit of study that was used in Fuss & O'Neill's modified base hydraulic model.

To more accurately assess the hydraulics of the River in the vicinity of the Bradford Dam for fish passage suitability, upstream wetland protection, and flood protection purposes; the modified base hydraulic model of the River was updated by Fuss & O'Neill as follows:

- USGS cross sections located between the Alton Bradford Road Bridge (RS67107.58) and the proposed downstream limit of disturbance (RS66520.49) were replaced and supplemented with 39 new cross sections based upon the results of an on-ground and aerial photogrammetric survey that was prepared for this project by National Land Surveyors, Inc. RIGIS 2-foot contours were used to supplement survey information in cases where the cross section limits extended outside of the limits of detailed survey. Refer to *Figures 5A-5G* for a depiction of all existing USGS and revised Fuss & O'Neill cross-sections used in the hydraulic analysis.

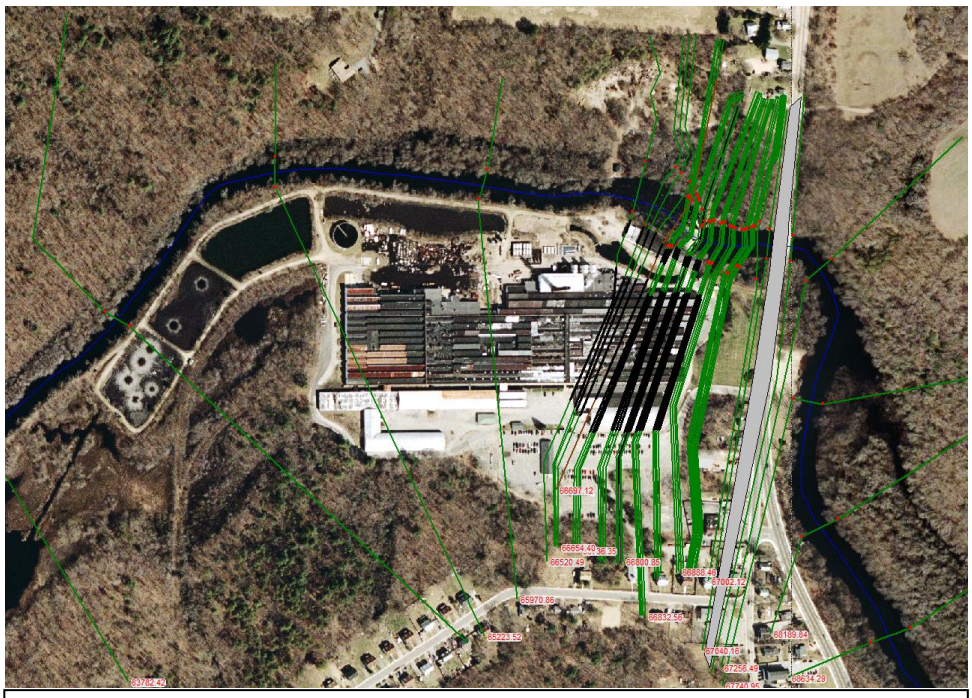

Illustration 8: Hydraulic cross-sections in the vicinity of Bradford Dam.

- USGS utilized channel and overbank roughness factors between Alton Bradford Road and the downstream limit of our detailed analysis that varied between 0.032 and 0.036 within channel areas and 0.07 and 0.10 within overbank areas. For purposes of analysis, Fuss & O'Neill did not modify Manning's roughness coefficients used by USGS in overbank areas. A value of 0.10 was used for left overbank areas and a value of 0.07 was used for right overbank areas. Fuss & O'Neill did, however, increase the roughness factor within the main channel in this location to 0.040 given the stony nature of the channel bottom leading up to and away from the Bradford Dam and relatively uneven nature of the channel bottom. Refer to *Appendix D* of this report for a copy of typical Manning's coefficients used in channel and overbank areas (as included in HEC-RAS Hydraulic Reference Manual Version 4.0, March 2008). Fuss & O'Neill did not modify any other channel or overbank roughness factors upstream or downstream of the immediate project limits/area.

- For purposes of analysis, Fuss & O'Neill did not modify cross section contraction and expansion coefficients used by USGS upstream of the Dam in its pre- and post-condition project models. However, Fuss & O'Neill did modify cross section contraction and expansion coefficients at the Dam and at sections downstream of the Dam within the immediate project limits between the Alton Bradford Bridge and downstream limit of disturbance within the pre-condition project model. Due

to the turbulence of flow that exists at the existing Dam and just downstream of the Dam due to the steep hydraulic gradient of the channel bottom in conjunction with the scour hole that has formed, the contraction and expansion coefficients from a point just upstream of the Bradford Dam (RS66796.01) to a point approximately 140 feet downstream of the Dam (RS66654.40) were increased from 0.3 and 0.5 to 0.6 an 0.8, respectively. These are typical values used where abrupt changes occur in the cross-sectional area or in the bottom elevation of the river channel..

As determined through analysis and reflected below, the Dam impounds flow (during base flow conditions) approximately 19,740 feet upriver to the location of the former Burdickville Dam.

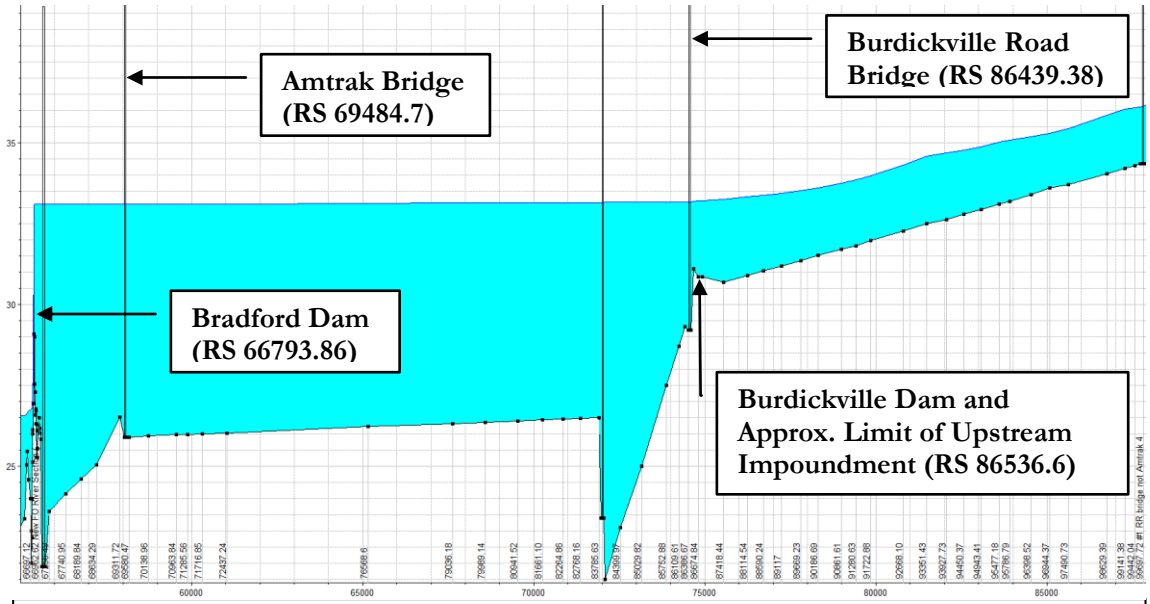

Illustration 9: Profile of River Reach Between the Bradford Dam and Burdickville Area during Base Flow Conditions

Pre-conditions or pre-dam removal water surface elevations and flow velocities during base flow conditions, selected flood flow events, and during the upstream fish migration season were computed and used as a basis for comparison for post-conditions or post-dam removal/rock ramp construction water surface elevations and flow velocities. Copies of all geometric input and output data used in our pre- dam removal HEC-RAS analysis have been included in *Appendix D* of this report.

It should be noted that our pre- and post-dam removal hydraulic analyses were performed under a mixed flow regime mode. When this mode is selected, HEC-RAS allows for subcritical flow, supercritical flow, hydraulic jumps, and drawdowns (as applicable).

When performing a mixed-flow regime analysis, starting boundary condition water surface elevations are necessary at the upstream and downstream limits of hydraulic analysis. For our pre- and post-conditions hydraulic analyses, known water surface elevations used at the downstream limit of study were approximated using the cross sectional geometry of the furthest downstream section, an average channel bottom slope of 0.004ft./ft., and a tailwater elevation equivalent to the Mean Higher High Water for Little Narragansett Bay (El. 1.2 feet NAVD88). These downstream boundary elevations were then compared to the transect stillwater elevations provided for Little Narragansett Bay within the current FIS for Washington County (October 16, 2013) for the 10-, 50-, 100-, and 500-year recurrence interval flood

events. In situations where the transect stillwater elevations were higher than the computed water surface elevation, the published transect stillwater elevations were conservatively utilized. It is important to understand that estimates of these downstream boundary water surface elevations are within the variance of the accepted analytical methods. Given the hydraulic gradient and distance (approximately 10.3 miles) of the River between the project area and downstream limit of hydraulic analysis, the water surface elevations applied at the downstream boundary do not impact modeling results within the project limits.

Similarly, the upstream limit of hydraulic analysis is approximately 7.3 miles upstream of the Bradford Dam. Given the relatively steep increase in channel bottom elevations and hydraulic gradient in the upper section of the River modeled between the former Burdickville Dam and upstream limit of hydraulic analysis, the selection of starting upstream water surface elevations is also not critical and will not impact modeling results within the project limits assuming such water surface approximations are relatively accurate. The water surface elevations used at the upstream boundary for the various dry-weather and wet-weather flows analyzed were determined through an iterative process. Initial upstream boundary water surface elevations were approximated and further refined until a convergence between the approximations and actual modeling results were achieved. The following table summarizes the water surface elevations utilized for the upstream and downstream boundary conditions.

Table 10:
Starting Upstream and Downstream Water Surface Boundary Conditions

Flow Event	Upstream Boundary (feet – NAVD88)	Downstream Boundary (feet – NAVD88)
Base Flow Conditions	39.06 feet	2.3 feet
Min. Operating Conditions	39.30 feet	2.6 feet
Normal Operating Conditions	40.56 feet	3.4 feet
Maximum Operating Conditions	43.09 feet	4.9 feet
1-Year	41.87 feet	4.0 feet
2-Year	43.56 feet	5.1 feet
10-Year	44.99 feet	6.7 feet
25-Year	45.82 feet	7.6 feet
50-Year	46.52 feet	9.6 feet
100-Year	47.58 feet	10.3 feet
500-Year	49.67 feet	18.7 feet[1]

Notes:

[1] This elevation reflects the 500-year stillwater elevation in Little Narragansett Bay as reported for coastal Transect 1 within the Flood Insurance Study for Washington County, Rhode Island (Revised October 16, 2013).

Detailed results of the pre-dam removal hydraulic model are provided in *Appendix D*.

4.5.3 Post-Conditions Hydraulic Model

As previously noted, the primary purpose of this project is to restore safe and effective fish passage at the Bradford Dam while protecting adjacent and upstream structures and natural resources and avoiding increases in flood elevations.

Due to the potential increases in flood elevations and/or reductions in base condition flow elevations that the installation of the rock ramp could cause if not carefully designed, the post-conditions hydraulic model was created. The post-dam removal hydraulic model was, therefore, used to design the layout of the rock ramp fishway and its components including the upstream grade control structure and notches, the width of the rock ramp fishway, and the vertical elevations of all stone weirs and associated notches.

In addition to the removal of the Dam, the post-conditions hydraulic model included the following revisions:

- Eight in-line weirs were added to the model to reflect the construction of the rock ramp fishway (at RS66972.36, RS66919.33, RS66865.35, RS66828.26, RS66793.86, RS66759.46, RS66719.96, and RS66520.49). The weirs were spaced at intervals of 30 feet from a point approximately 150 feet upstream of the previous dam location to a point approximately 60 feet downstream of the previous dam location. The most upstream in-line weir (Weir #1 at RS66972.36) represents the steel sheet cutoff that is proposed as the upstream grade control structure. The remaining seven weirs downstream of Weir #1 represent the proposed, raised arched stone weirs. Each of the weirs has been designed with a 10-foot wide low-level notch having an invert elevation that is 30 inches below the top of each weir. Each of the weirs has also been designed with two 5-foot wide upper-level notches having inverts of 9-inches and 12-inches below the top of each weir.

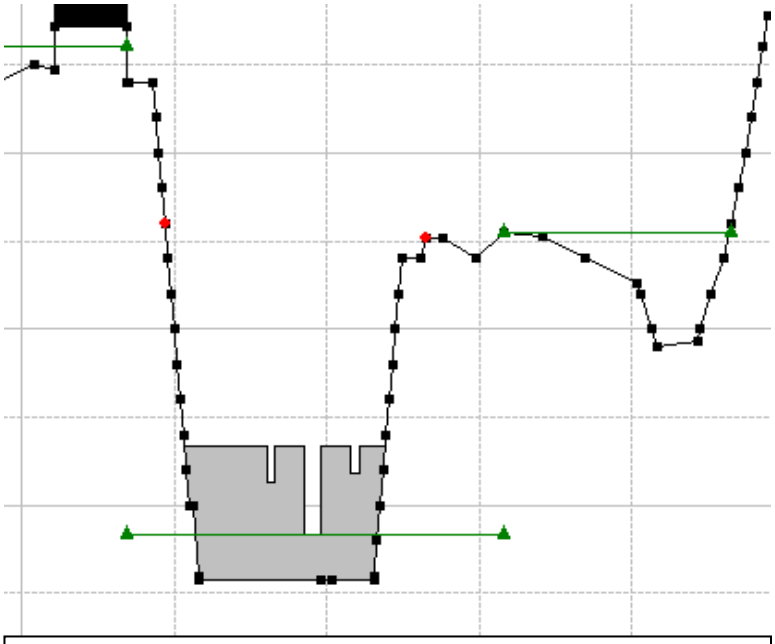

Illustration 10: Typical Rock Ramp Weir with Notches for Fish Passage

- It must be understood that the furthest downstream weir (Weir #8) was only proposed to accommodate the potential (future) partial or full removal of the Potter Hill Dam. This weir will be fully submerged under all flow conditions with exception to periods of extreme low flow. It is anticipated that the partial or full removal of the Potter Hill Dam will result in a tailwater elevation reduction of approximately 9 inches under minimum operating conditions. This weir will ensure that adequate fish passage will be achieved under that future scenario. Additionally, the channel bottom downstream of the rock ramp fishway (at RS66520.49, RS66586.04, RS66611.50, and RS66654.40) was excavated to provide approximately 30-inches of flow depth under minimum operating conditions subsequent to the potential (future) removal of the Potter Hill Dam.

- The geometry of all cross sections within the limits of the rock ramp fishway were revised to reflect the proposed grades/channel bottoms within each pool of the rock ramp fishway that was necessary to achieve a minimum of four feet of flow depth under minimum operating

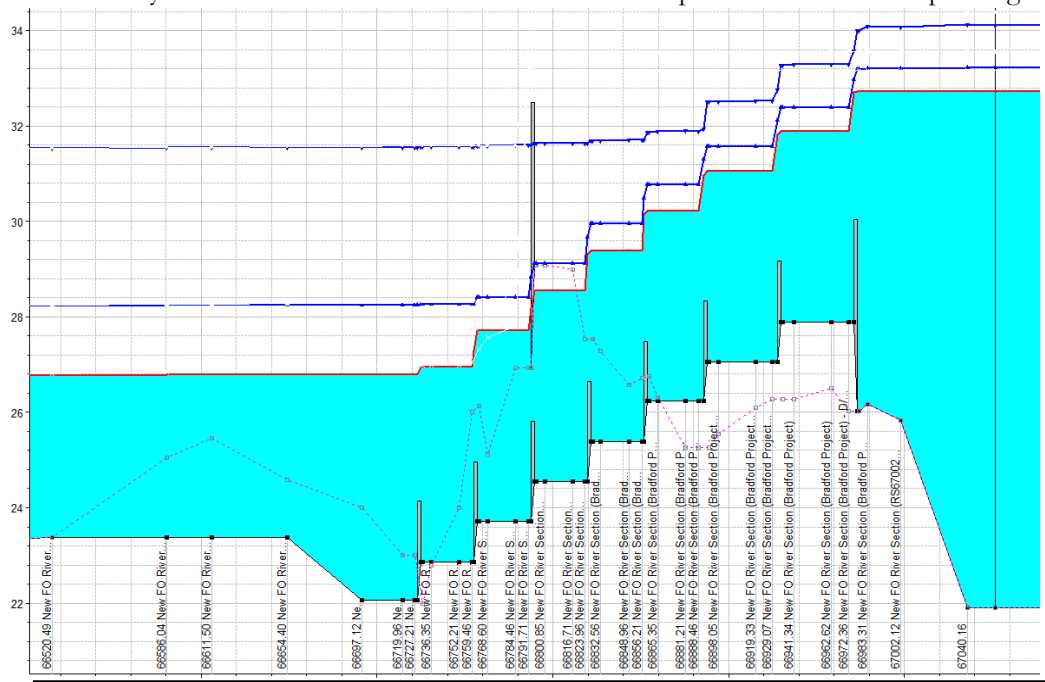

Illustration 11: Profile of Rock Ramp and Four-Foot Deep Pools

conditions.

- Ineffective flow areas have been added at each section within the limits of the rock ramp fishway including those sections immediately upstream and downstream of the each in-line weir. The ineffective flow area elevations were established such that flow beneath the invert of each successive stone weir low-flow notch was considered ineffective. Ineffective flow areas are areas within a cross section that will contain water that is not actively being conveyed.

- The 0.6 and 0.8 contraction and expansion coefficients utilized in the pre-conditions hydraulic model at the existing Dam and in the turbulent 140-foot stretch of river downstream of the Dam, were revised to 0.3 and 0.5, respectively, since the rock ramp was designed with a uniform slope and all hydraulic drops across all weirs were limited to 10 inches or less.

- Cross sections within the limits of the rock ramp fishway were also revised to reflect the filling in of the inlet to the Millrace channel, excavation proposed along the river right to accommodate the widened river channel, and fill proposed along the river left to protect the foundation of the adjacent former Mill during flood events.

The following table provides a comparison of pre- and post-dam removal water surface elevations at select locations between the upstream and downstream limits of hydraulic analysis during base flow conditions and various flood recurrence intervals. The elevation listed in the table corresponds to the pre-project condition water surface elevations while the value below it in parentheses indicates the anticipated change in water surface elevations in units of feet as a result of the dam removal and the construction of the rock ramp fishway.

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Table 11:
Pre- Versus Post-Project Conditions Water Surface Elevation Summary Table

Location Description	Station	Water Surface Elevations							
		Base Flow	1-Year Storm	2-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm	500-Year Storm
U/S Limit of Analysis 200' D/S of Kings Factory Road Bridge	104355.5	38.38 (0.00)	41.36 (0.00)	43.13 (0.00)	44.42 (0.00)	45.14 (0.00)	45.76 (0.00)	46.44 (0.00)	48.21 (0.00)
20' U/S of Amtrak Railroad Bridge #4	99717.16	36.13 (0.00)	39.38 (-0.01)	41.28 (-0.01)	42.79 (-0.01)	43.72 (0.00)	44.49 (-0.01)	45.28 (0.00)	47.24 (-0.01)
Amtrak Railroad Bridge #4 – RS 99697.72									
50' D/S of Amtrak Railroad Bridge #4	99648.13	36.11 (0.00)	39.37 (-0.01)	41.26 (0.00)	42.77 (-0.01)	43.70 (-0.01)	44.46 (0.00)	45.26 (-0.01)	47.20 (0.00)
D/S of Confluence with Wood River	92668.1	34.31 (-0.05)	37.34 (-0.03)	39.36 (-0.03)	41.46 (-0.01)	42.53 (-0.01)	43.33 (-0.01)	44.15 (-0.01)	46.10 (0.00)
1,700' U/S of Burdickville Dam	89117.00	33.44 (-0.27)	35.92 (-0.09)	37.77 (-0.06)	39.80 (-0.03)	40.85 (-0.01)	41.66 (-0.02)	42.50 (-0.02)	44.75 (-0.01)
At Burdickville Dam	87418.44	33.25 (-0.38)	35.35 (-0.14)	37.14 (-0.08)	39.08 (-0.04)	40.08 (-0.02)	40.87 (-0.02)	41.74 (-0.02)	44.15 (-0.01)
20' U/S of Burdickville Road Bridge	86457.04	33.17 (-0.48)	35.04 (-0.18)	36.83 (-0.10)	38.72 (-0.05)	39.70 (-0.03)	40.46 (-0.03)	41.30 (-0.02)	43.71 (-0.02)
Burdickville Road Bridge – RS 86439.38									
50' D/S of Burdickville Road Bridge	86386.67	33.16 (-0.47)	35.01 (-0.18)	36.78 (-0.10)	38.61 (-0.05)	39.54 (-0.04)	40.25 (-0.03)	41.03 (-0.02)	42.88 (-0.01)
10' U/S of Amtrak Railroad Bridge #3	83911.23	33.15 (-0.48)	34.88 (-0.19)	36.56 (-0.12)	38.24 (-0.06)	39.05 (-0.04)	39.67 (-0.04)	40.35 (-0.02)	42.09 (-0.02)
Amtrak Railroad Bridge #3 – RS 83899.99									
55' D/S of Amtrak Railroad Bridge #3	83845.99	33.15 (-0.48)	34.88 (-0.20)	36.55 (-0.12)	38.22 (-0.06)	39.02 (-0.03)	39.64 (-0.03)	40.32 (-0.02)	42.05 (-0.02)
D/S of Confluence with Poquiant Brook	76568.60	33.12 (-0.48)	34.49 (-0.24)	35.80 (-0.16)	37.42 (-0.09)	38.26 (-0.06)	38.95 (-0.06)	39.73 (-0.04)	41.71 (-0.03)
20' U/S of Amtrak Railroad Bridge #2	69502.02	33.10 (-0.49)	34.07 (-0.28)	34.85 (-0.22)	35.98 (-0.25)	36.90 (-0.16)	37.71 (-0.12)	38.59 (-0.07)	40.70 (-0.04)
Amtrak Railroad Bridge #2 – RS 69484.70									
50' D/S of Amtrak Railroad Bridge #2	69437.49	33.10 (-0.49)	34.06 (-0.28)	34.82 (-0.23)	35.92 (-0.27)	36.81 (-0.16)	37.61 (-0.12)	38.48 (-0.07)	40.55 (-0.04)
Bradford Boat Launch	67740.95	33.10 (-0.50)	34.00 (-0.29)	34.68 (-0.25)	35.63 (-0.31)	36.48 (-0.19)	37.27 (-0.14)	38.15 (-0.09)	40.28 (-0.05)
17' U/S of Alton Bradford Road Bridge	67124.53	33.10 (-0.50)	33.98 (-0.29)	34.62 (-0.25)	35.49 (-0.32)	36.28 (-0.20)	37.02 (-0.15)	37.83 (-0.09)	40.00 (-0.04)
Alton Bradford Road Bridge – RS 67107.58									
67' D/S of Alton Bradford Road Bridge	67040.16	33.09 (-0.49)	33.97 (-0.29)	34.59 (-0.26)	35.40 (-0.32)	36.14 (-0.20)	36.83 (-0.15)	37.59 (-0.09)	39.41 (-0.04)
105' D/S of Alton Bradford Road Bridge	67002.12	33.09 -(0.49)	33.95 -(0.30)	34.54 -(0.26)	35.32 -(0.35)	36.08 -(0.22)	36.82 -(0.17)	37.60 -(0.10)	39.45 -(0.04)
124' D/S of Alton Bradford Road Bridge	66983.31	33.09 -(0.49)	33.95 -(0.30)	34.54 -(0.25)	35.32 -(0.32)	36.09 -(0.19)	36.83 -(0.14)	37.61 -(0.07)	39.46 -(0.03)
129' D/S of Alton Bradford Road Bridge	66978.14	33.09 -(0.50)	33.95 -(0.35)	34.54 -(0.36)	35.32 -(0.50)	36.09 -(0.32)	36.83 -(0.23)	37.61 -(0.14)	39.46 -(0.06)

Location Description	Station	Water Surface Elevations							
		Base Flow	1-Year Storm	2-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm	500-Year Storm
Location of Proposed Fishway Weir #1 – RS 66975.25									
179' U/S of Bradford Dam	66972.36	33.09	33.95	34.54	35.32	36.09	36.83	37.61	39.46
		-(1.32)	-(1.11)	-(1.00)	-(0.60)	-(0.33)	-(0.24)	-(0.15)	-(0.07)
169' U/S of Bradford Dam	66962.62	33.09	33.95	34.54	35.32	36.08	36.82	37.61	39.44
		-(1.32)	-(1.11)	-(1.00)	-(0.60)	-(0.32)	-(0.23)	-(0.15)	-(0.05)
147' U/S of Bradford Dam	66941.34	33.09	33.95	34.53	35.32	36.09	36.83	37.61	39.45
		-(1.32)	-(1.12)	-(1.01)	-(0.63)	-(0.35)	-(0.25)	-(0.16)	-(0.07)
140' U/S of Bradford Dam	66934.84	33.09	33.95	34.53	35.31	36.08	36.83	37.61	39.44
		-(1.32)	-(1.12)	-(1.02)	-(0.62)	-(0.34)	-(0.25)	-(0.16)	-(0.07)
Location of Proposed Fishway Weir #2 – RS 66931.96									
135' U/S of Bradford Dam	66929.07	33.09	33.94	34.53	35.31	36.08	36.83	37.61	39.44
		-(2.17)	-(1.89)	-(1.73)	-(0.69)	-(0.38)	-(0.29)	-(0.19)	-(0.08)
125' U/S of Bradford Dam	66919.33	33.09	33.94	34.53	35.32	36.09	36.83	37.61	39.44
		-(2.17)	-(1.89)	-(1.73)	-(0.70)	-(0.39)	-(0.29)	-(0.19)	-(0.07)
104' U/S of Bradford Dam	66898.05	33.09	33.94	34.53	35.31	36.08	36.82	37.61	39.44
		-(2.17)	-(1.90)	-(1.74)	-(0.70)	-(0.39)	-(0.29)	-(0.20)	-(0.07)
99' U/S of Bradford Dam	66892.76	33.09	33.94	34.53	35.31	36.08	36.83	37.61	39.44
		-(2.17)	-(1.90)	-(1.75)	-(0.70)	-(0.39)	-(0.30)	-(0.20)	-(0.08)
Location of Proposed Fishway Weir #3 – RS 66890.61									
95' U/S of Bradford Dam	66888.46	33.09	33.94	34.53	35.31	36.08	36.83	37.61	39.44
		-(3.00)	-(2.67)	-(1.99)	-(0.73)	-(0.41)	-(0.32)	-(0.22)	-(0.09)
87' U/S of Bradford Dam	66881.21	33.09	33.94	34.53	35.31	36.09	36.83	37.61	39.45
		-(3.00)	-(2.67)	-(1.98)	-(0.72)	-(0.42)	-(0.32)	-(0.22)	-(0.10)
71' U/S of Bradford Dam	66865.35	33.09	33.94	34.52	35.28	36.05	36.79	37.58	39.40
		-(3.00)	-(2.68)	-(1.99)	-(0.71)	-(0.39)	-(0.29)	-(0.20)	-(0.07)
67' U/S of Bradford Dam	66860.51	33.09	33.94	34.52	35.28	36.05	36.79	37.58	39.40
		-(3.00)	-(2.68)	-(2.00)	-(0.71)	-(0.39)	-(0.29)	-(0.19)	-(0.07)
Location of Proposed Fishway Weir #4 – RS 66858.36									
62' U/S of Bradford Dam	66856.21	33.09	33.94	34.52	35.28	36.05	36.79	37.58	39.40
		-(3.83)	-(3.48)	-(2.07)	-(0.72)	-(0.41)	-(0.31)	-(0.22)	-(0.10)
55' U/S of Bradford Dam	66848.96	33.09	33.94	34.52	35.28	36.05	36.79	37.58	39.40
		-(3.83)	-(3.48)	-(2.06)	-(0.72)	-(0.41)	-(0.31)	-(0.22)	-(0.09)
39' U/S of Bradford Dam	66832.56	33.09	33.93	34.51	35.27	36.03	36.78	37.57	39.39
		-(3.83)	-(3.47)	-(2.06)	-(0.71)	-(0.39)	-(0.30)	-(0.21)	-(0.09)
34' U/S of Bradford Dam	66828.26	33.09	33.93	34.50	35.26	36.03	36.77	37.56	39.39
		-(3.83)	-(3.47)	-(2.05)	-(0.70)	-(0.39)	-(0.29)	-(0.20)	-(0.09)
Location of Proposed Fishway Weir #5 – RS 66826.11									
30' U/S of Bradford Dam	66823.96	33.09	33.92	34.49	35.24	36.01	36.76	37.55	39.39
		-(4.68)	-(3.91)	-(2.08)	-(0.70)	-(0.39)	-(0.30)	-(0.22)	-(0.12)
23' U/S of Bradford Dam	66816.71	33.09	33.91	34.47	35.20	35.98	36.74	37.53	39.37
		-(4.67)	-(3.90)	-(2.06)	-(0.66)	-(0.36)	-(0.28)	-(0.20)	-(0.10)
7' U/S of Bradford Dam	66800.85	33.09	33.88	34.42	35.13	35.93	36.69	37.49	39.35
		-(4.68)	-(3.88)	-(2.02)	-(0.60)	-(0.32)	-(0.24)	-(0.17)	-(0.09)
2' U/S of Bradford Dam	66796.01	33.06	33.76	34.23	34.87	35.75	36.55	37.39	39.30
		-(4.65)	-(3.76)	-(1.83)	-(0.35)	-(0.15)	-(0.11)	-(0.08)	-(0.05)
Location of Former Bradford Dam and Proposed Fishway Weir #6 – RS 66793.86									
2' D/S of Bradford Dam	66791.71	32.94	33.45	33.89	34.62	35.63	36.45	37.31	39.26
		-(5.38)	-(3.52)	-(1.52)	-(0.13)	-(0.05)	-(0.04)	-(0.03)	-(0.03)
9' D/S of Bradford Dam	66784.46	27.67	29.49	32.35	34.48	35.57	36.41	37.28	39.24
		-(0.11)	(0.44)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	-(0.02)

Location Description	Station	Water Surface Elevations							
		Base Flow	1-Year Storm	2-Year Storm	10-Year Storm	25-Year Storm	50-Year Storm	100-Year Storm	500-Year Storm
25' D/S of Bradford Dam	66768.60	27.45	29.92	32.35	34.48	35.57	36.41	37.28	39.24
		(0.11)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	-(0.02)
30' D/S of Bradford Dam	66763.76	27.33	29.92	32.35	34.48	35.57	36.41	37.28	39.24
		(0.23)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	-(0.02)
Location of Proposed Fishway Weir #7 – RS 66761.61									
34' D/S of Bradford Dam	66759.46	26.96	29.92	32.35	34.48	35.57	36.41	37.28	39.24
		-(0.18)	-(0.03)	-(0.01)	-(0.01)	-(0.01)	-(0.02)	-(0.01)	-(0.03)
42' D/S of Bradford Dam	66752.21	26.77	29.92	32.35	34.48	35.57	36.40	37.28	39.23
		(0.01)	-(0.03)	-(0.01)	-(0.01)	-(0.01)	(0.00)	-(0.01)	-(0.02)
58' D/S of Bradford Dam	66736.35	26.77	29.92	32.35	34.48	35.56	36.40	37.28	39.23
		(0.01)	-(0.03)	-(0.01)	-(0.01)	(0.00)	-(0.01)	-(0.02)	-(0.02)
62' D/S of Bradford Dam	66731.51	26.76	29.92	32.35	34.48	35.56	36.40	37.27	39.23
		(0.02)	-(0.03)	-(0.01)	-(0.01)	-(0.01)	-(0.01)	-(0.01)	-(0.02)
Location of Proposed Fishway Weir #8 – RS 66729.36									
67' D/S of Bradford Dam	66727.21	26.76	29.92	32.35	34.48	35.56	36.40	37.27	39.23
		(-0.22)	(-0.04)	(-0.03)	(-0.03)	(-0.02)	(-0.02)	(-0.02)	(-0.03)
74' D/S of Bradford Dam	66719.96	26.76	29.92	32.35	34.48	35.56	36.40	37.27	39.23
		(-0.22)	(-0.04)	(-0.03)	(-0.03)	(-0.02)	(-0.02)	(-0.02)	(-0.03)
97' D/S of Bradford Dam	66697.12	26.75	29.91	32.34	34.47	35.56	36.40	37.27	39.23
		(-0.21)	(-0.03)	(-0.02)	(-0.02)	(-0.02)	(-0.02)	(-0.02)	(-0.03)
139' D/S of Bradford Dam	66654.40	26.71	29.89	32.33	34.46	35.54	36.38	37.25	39.20
		(-0.17)	(-0.01)	(-0.01)	(-0.01)	(0.00)	(-0.01)	(-0.01)	(-0.01)
182' D/S of Bradford Dam	66611.50	26.64	29.88	32.32	34.45	35.53	36.37	37.24	39.19
		(-0.10)	(-0.01)	(-0.01)	(-0.01)	(0.00)	(0.00)	(0.00)	(0.00)
208' D/S of Bradford Dam	66586.04	26.60	29.87	32.31	34.45	35.53	36.37	37.24	39.19
		(-0.06)	(0.00)	(0.00)	(-0.01)	(-0.01)	(-0.02)	(-0.02)	(-0.02)
273' D/S of Bradford Dam	66520.49	26.57	29.86	32.30	34.42	35.50	36.33	37.19	39.12
		(-0.04)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(-0.01)	(0.00)
D/S Limit of Analysis 823' D/S of Bradford Dam	65970.86	26.49	29.79	32.21	34.29	35.35	36.16	37.03	38.99
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes:

1. Values in parentheses indicate the anticipated change in water surface elevations in units of feet as compared to pre-project conditions.
2. Values in red italics indicated isolated locations of minor increases in water surface elevations as compared to pre-project conditions.

In spite of the proposed fill being placed to block the inlet of the Millrace channel and to protect the foundation of the adjacent Mill building, the project will result in the net removal of approximately 2,270 cubic yards of material from within the River and its floodplain. This net removal of material from the river channel and its riverbanks will increase the River's conveyance capacity within the section of River to a point extending approximately 7.1 miles upstream of the Dam. It also allows the project to avoid increases in 100-year flood elevations in all location throughout the Project reach.

As illustrated in *Table 14*, the Project will improve flood protection benefits to bordering, developed properties along the River throughout this 7.1-mile stretch of the Pawcatuck River between the Bradford Dam and King's Factory Road Bridge during flood events. This will be achieved as a result of:

- designing the top elevation of the upstream grade control structure (El. 32.54 feet), referred to was Weir #1 of the rock ramp fishway, to match the invert elevation of the existing Dam's spillway (which varies between El. 32.50 and El. 32.60);
- widening the river channel throughout the Project limits to achieve a minimum natural channel width ranging between 120 feet to 130 feet under low-flow or base conditions; and
- increasing the effective length of flow over the upstream grade control structure (at El. 32.54 feet) from approximately 73 feet (the approximate width of the lower section of the Dam's spillway) to 170 feet (the approximate width of the top of the grade control structure).

The following illustrations of the River's profile within the project limits (as obtained from HEC-RAS) demonstrates post-dam removal water surface elevations will not exceed pre-dam removal water surface elevations during the 100-year recurrence interval flood event between the downstream limit of study and the Alton Bradford Road Bridge:

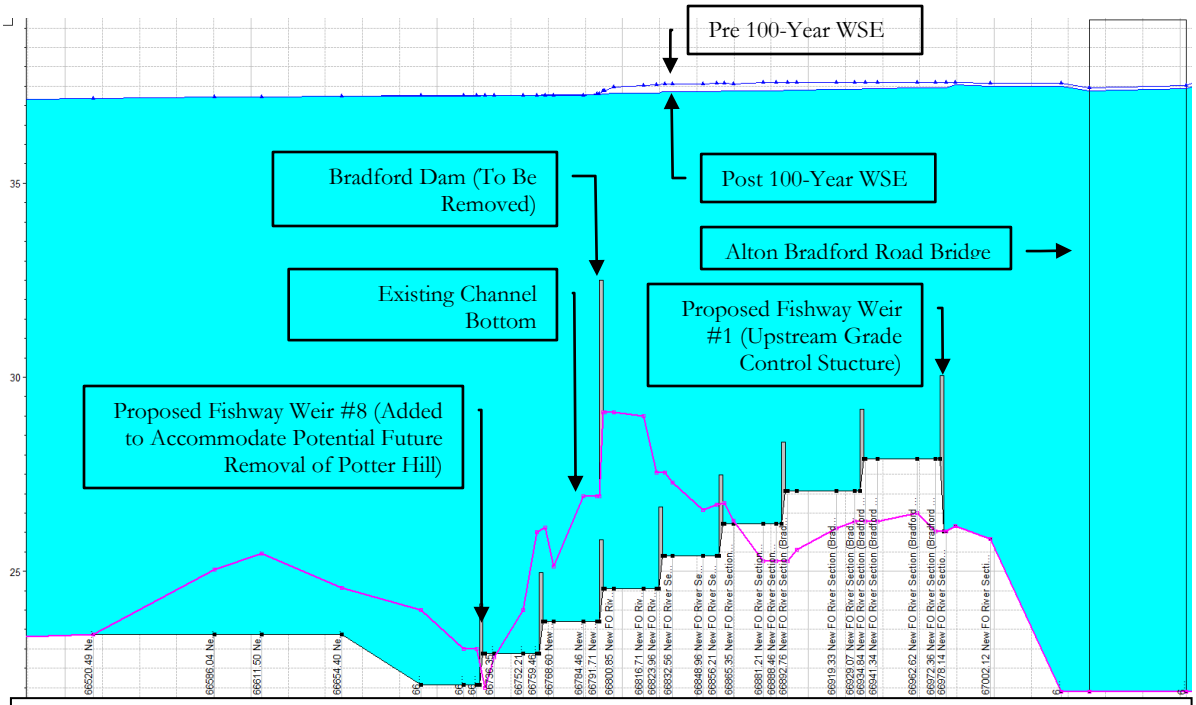

Illustration 12: Profile of River Reach between the D/S Hydraulic Limit and Alton Bradford Road during 100-Year Flood

The post-conditions hydraulic model was also used to assess/quantify potential impacts to upstream wetland and groundwater resources as a result of reductions in base flow condition water levels upstream of the removed dam and proposed rock ramp fishway. Changes of more than six inches in base condition water surface elevations may potentially result in significant ecological changes to adjacent wetland communities depending on the amount of surface runoff discharged to each wetland in addition to the wetland's underlying soils, depth to groundwater, and frequency of seasonal flooding/inundation.

As reflected in *Table 14*, the rock ramp fishway's upstream weir was designed to function as a grade control structure that would limit upstream reductions in base condition water levels to less than six inches in order to avoid impacts to sensitive upstream wetland resources. The following illustration of the River's profile upstream of the Alton Bradford Road Bridge (as obtained from HEC-RAS)

demonstrates the anticipated changes in base condition water surface elevations will be limited to six inches or less:

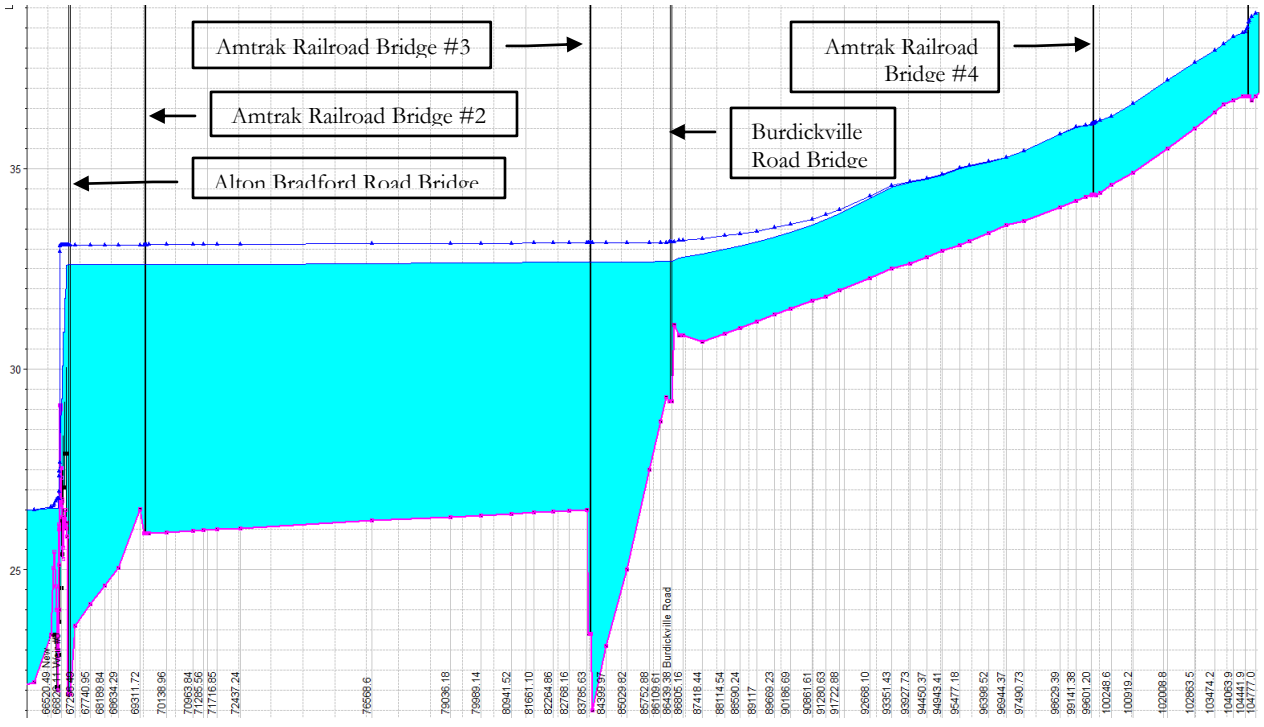

Illustration 13: Profile of River Reach between the D/S Hydraulic Limit and King's Factory Road during Base Flow Conditions

The only location where base elevations will change by more than six inches is within a 180-foot stretch of the River (within the Project's limit of disturbance) between proposed Weir 1 and Weir 6 of the rock ramp fishway. Since the majority of the fishway was located upstream of the existing Dam in order to avoid local increases in 100-year floodplain elevations, significant base condition water surface elevation drops were limited to this one on-site section of the River. Due to the hydric nature of the soils underlying the three adjacent swamps, it is not anticipated that the character of these on-site wetlands will be altered.

- The adjacent swamp on river left, is underlain by Ridgebury, Whitman, and Leicester extremely stony fine sandy loams (Rf). Since the proposed fishway Weir #1 will be located just downstream of this wetland, the section of river bordering this wetland will only experience a reduction in base condition water surface elevations of approximately six inches which is not anticipated to impact the natural character of this wetland system.
- The lower (western) swamp on river right is underlain by Rumney fine sandy loam (Ru). The section of river bordering this lower swamp will only experience a reduction in base condition water surface elevations of approximately 0.2 feet (3 inches) or less which is not anticipated to impact the natural character of this wetland system.
- The upper (eastern) swamp on river right is also underlain by Rumney fine sandy loam (Ru). Although portions of the section of river bordering this upper swamp will experience a more significant reduction in base condition water surface elevations ranging between 1.3 feet to 5.4 feet, the easternmost end of the swamp still borders the section of the river where base

condition water surface elevations will drop by less than six inches. The approximate elevation of the base condition water level is approximately El. 33.0. Since ground elevations within this Swamp are below this elevation, it is our opinion that the natural character of this wetland system will also remain unaltered. Groundwater will still result in the seasonal to permanent saturation of the majority of this wetland (i.e. given the hydric nature of soils).

Additionally, the post-conditions hydraulic model was used to design the weirs and pools associated with the rock ramp fishway in order to assure that the fishway would provide safe and effective fish passage following dam removal. As discussed in *Section 4.2.1*, the cruising speed of the target species is 2.8 feet per second. This is the speed that can be maintained by a particular fish species for greater than 200 minutes (essentially, indefinitely). Therefore, this criterion was used to confirm that the flow velocities in the pools between the weirs did not exceed this value. The following table reflects average flow velocities for each section within the natural river channel (post-dam removal) under minimum, normal, and maximum operating condition flows (subsequent to the incorporation of resting areas/pools):

Table 12:
Rock Ramp Fishway Flow Velocities and Pool Depths
During Minimum, Normal, and Maximum Operating Conditions

River Station	Flow Condition	Q Total (cfs)	Min. Channel El. (ft.)	W.S. Elev (ft.)	Max. Channel Depth (ft.)	Avg. Velocity in Section (ft/s)
671057.58	Alton Bradford Road Bridge					
67040.16	Min Op	218.00	21.90	32.73	10.83	0.27
67040.16	Norm Op	524.00	21.90	33.22	11.32	0.62
67040.16	Max Op	1414.00	21.90	34.12	12.22	1.53
67002.12	Min Op	221.00	25.83	32.72	6.89	0.43
67002.12	Norm Op	531.00	25.83	33.21	7.38	0.94
67002.12	Max Op	1434.00	25.83	34.08	8.25	2.08
66983.31	Min Op	221.00	26.17	32.73	6.56	0.37
66983.31	Norm Op	531.00	26.17	33.21	7.04	0.77
66983.31	Max Op	1434.00	26.17	34.09	7.92	1.68
66978.14	Min Op	221.00	26.02	32.72	6.70	0.71
66978.14	Norm Op	531.00	26.02	33.19	7.17	1.34
66978.14	Max Op	1434.00	26.02	34.00	7.98	2.61
66975.25	Rock Ramp Fishway Weir #1 / Upstream Grade Control Structure					
66972.36	Min Op	221.00	27.89	31.89	4.00	0.57
66972.36	Norm Op	531.00	27.89	32.39	4.50	1.12
66972.36	Max Op	1434.00	27.89	33.30	5.41	2.24
66962.62	Min Op	221.00	27.89	31.89	4.00	0.49
66962.62	Norm Op	531.00	27.89	32.39	4.50	0.98
66962.62	Max Op	1434.00	27.89	33.30	5.41	2.04
66941.34	Min Op	221.00	27.89	31.89	4.00	0.50

River Station	Flow Condition	Q Total (cfs)	Min. Channel El. (ft.)	W.S. Elev (ft.)	Max. Channel Depth (ft.)	Avg. Velocity in Section (ft/s)
66941.34	Norm Op	531.00	27.89	32.38	4.49	1.01
66941.34	Max Op	1434.00	27.89	33.28	5.39	2.10
66934.84	Min Op	221.00	27.89	31.89	4.00	0.50
66934.84	Norm Op	531.00	27.89	32.38	4.49	1.02
66934.84	Max Op	1434.00	27.89	33.28	5.39	2.12
66931.96	Fishway Weir #2					
66929.07	Min Op	221.00	27.06	31.06	4.00	0.60
66929.07	Norm Op	531.00	27.06	31.57	4.51	1.18
66929.07	Max Op	1434.00	27.06	32.52	5.46	2.35
66919.33	Min Op	221.00	27.06	31.06	4.00	0.52
66919.33	Norm Op	531.00	27.06	31.57	4.51	1.04
66919.33	Max Op	1434.00	27.06	32.52	5.46	2.14
66898.05	Min Op	221.00	27.06	31.06	4.00	0.52
66898.05	Norm Op	531.00	27.06	31.56	4.50	1.05
66898.05	Max Op	1434.00	27.06	32.51	5.45	2.17
66892.76	Min Op	221.00	27.06	31.05	3.99	0.52
66892.76	Norm Op	531.00	27.06	31.56	4.50	1.05
66892.76	Max Op	1434.00	27.06	32.51	5.45	2.17
66890.61	Fishway Weir #3					
66888.46	Min Op	221.00	26.23	30.22	3.99	0.63
66888.46	Norm Op	531.00	26.23	30.78	4.55	1.21
66888.46	Max Op	1434.00	26.23	31.90	5.67	2.31
66881.21	Min Op	221.00	26.23	30.22	3.99	0.53
66881.21	Norm Op	531.00	26.23	30.78	4.55	1.06
66881.21	Max Op	1434.00	26.23	31.90	5.67	2.10
66865.35	Min Op	221.00	26.23	30.22	3.99	0.56
66865.35	Norm Op	531.00	26.23	30.77	4.54	1.11
66865.35	Max Op	1434.00	26.23	31.88	5.65	2.21
66860.51	Min Op	221.00	26.23	30.22	3.99	0.57
66860.51	Norm Op	531.00	26.23	30.77	4.54	1.13
66860.51	Max Op	1434.00	26.23	31.88	5.65	2.25
66858.36	Fishway Weir #4					
66856.21	Min Op	221.00	25.39	29.39	4.00	0.69
66856.21	Norm Op	531.00	25.39	29.95	4.56	1.33
66856.21	Max Op	1434.00	25.39	31.70	6.31	2.17
66848.96	Min Op	221.00	25.39	29.39	4.00	0.59
66848.96	Norm Op	531.00	25.39	29.95	4.56	1.17

River Station	Flow Condition	Q Total (cfs)	Min. Channel El. (ft.)	W.S. Elev (ft.)	Max. Channel Depth (ft.)	Avg. Velocity in Section (ft/s)
66848.96	Max Op	1434.00	25.39	31.71	6.32	2.01
66832.56	Min Op	221.00	25.39	29.39	4.00	0.59
66832.56	Norm Op	531.00	25.39	29.95	4.56	1.16
66832.56	Max Op	1434.00	25.39	31.70	6.31	2.00
66828.26	Min Op	221.00	25.39	29.39	4.00	0.59
66828.26	Norm Op	531.00	25.39	29.95	4.56	1.16
66828.26	Max Op	1434.00	25.39	31.70	6.31	2.00
66826.11	Fishway Weir #5					
66823.96	Min Op	221.00	24.55	28.55	4.00	0.71
66823.96	Norm Op	531.00	24.55	29.12	4.57	1.35
66823.96	Max Op	1434.00	24.55	31.64	7.09	1.88
66816.71	Min Op	221.00	24.55	28.55	4.00	0.60
66816.71	Norm Op	531.00	24.55	29.12	4.57	1.19
66816.71	Max Op	1434.00	24.55	31.64	7.09	1.76
66800.85	Min Op	221.00	24.55	28.55	4.00	0.61
66800.85	Norm Op	531.00	24.55	29.12	4.57	1.21
66800.85	Max Op	1434.00	24.55	31.64	7.09	1.79
66796.01	Min Op	221.00	24.55	28.55	4.00	0.61
66796.01	Norm Op	531.00	24.55	29.11	4.56	1.21
66796.01	Max Op	1434.00	24.55	31.63	7.08	1.79
66793.86	Fishway Weir #6 / Former Dam Location					
66791.71	Min Op	221.00	23.71	27.71	4.00	0.74
66791.71	Norm Op	531.00	23.71	28.41	4.70	1.35
66791.71	Max Op	1434.00	23.71	31.60	7.89	1.69
66784.46	Min Op	221.00	23.71	27.71	4.00	0.68
66784.46	Norm Op	531.00	23.71	28.41	4.70	1.29
66784.46	Max Op	1434.00	23.71	31.60	7.89	1.72
66768.6	Min Op	221.00	23.71	27.71	4.00	0.70
66768.6	Norm Op	531.00	23.71	28.41	4.70	1.32
66768.6	Max Op	1434.00	23.71	31.59	7.88	1.76
66763.76	Min Op	221.00	23.71	27.71	4.00	0.67
66763.76	Norm Op	531.00	23.71	28.41	4.70	1.26
66763.76	Max Op	1434.00	23.71	31.59	7.88	1.68
66761.61	Fishway Weir #7					
66759.46	Min Op	221.00	22.87	26.95	4.08	0.75
66759.46	Norm Op	531.00	22.87	28.27	5.40	1.13
66759.46	Max Op	1434.00	22.87	31.57	8.70	1.54

River Station	Flow Condition	Q Total (cfs)	Min. Channel El. (ft.)	W.S. Elev (ft.)	Max. Channel Depth (ft.)	Avg. Velocity in Section (ft/s)
66752.21	Min Op	221.00	22.87	26.95	4.08	0.62
66752.21	Norm Op	531.00	22.87	28.27	5.40	0.99
66752.21	Max Op	1434.00	22.87	31.58	8.71	1.41
66736.35	Min Op	221.00	22.87	26.95	4.08	0.62
66736.35	Norm Op	531.00	22.87	28.27	5.40	0.99
66736.35	Max Op	1434.00	22.87	31.57	8.70	1.42
66731.51	Min Op	221.00	22.87	26.95	4.08	0.62
66731.51	Norm Op	531.00	22.87	28.27	5.40	1.00
66731.51	Max Op	1434.00	22.87	31.57	8.70	1.42
66729.36	Fishway Weir #8 (Installed to Accommodate Potential Future Removal of Potter Hill)					
66727.21	Min Op	221.00	22.07	26.79	4.72	0.49
66727.21	Norm Op	531.00	22.07	28.25	6.18	0.82
66727.21	Max Op	1434.00	22.07	31.55	9.48	1.27
66719.96	Min Op	221.00	22.07	26.79	4.72	0.45
66719.96	Norm Op	531.00	22.07	28.25	6.18	0.77
66719.96	Max Op	1434.00	22.07	31.55	9.48	1.23
66697.12	Min Op	221.00	22.07	26.79	4.72	0.40
66697.12	Norm Op	531.00	22.07	28.25	6.18	0.69
66697.12	Max Op	1434.00	22.07	31.55	9.48	1.11
66654.5	End of Fishway Pool					

As reflected in *Table 12,* the analysis demonstrates adequate depths for suitable fish passage will exist following the removal of the Dam and installation of the rock ramp fishway as pool flow depths will exceed 4.0 feet under minimum operating conditions, normal operating conditions, and maximum operating conditions. The analysis also demonstrates that flow velocities within the pools of the rock ramp will not exceed 2.8 feet per second. Hydraulic drops across each weir has been limited to 0.84 feet (10 inches) or less. It is also important to note that Weir #8 is being proposed strictly to accommodate the hydraulic drop that is expected to occur in the River downstream of the rock ramp fishway should Potter Hill be removed in the future. The tailwater elevation (at the downstream end of the fishway) is expected to drop by approximately 9 inches (to El. 26.07 feet) under minimum operating conditions should Potter Hill be removed.

Flow velocity changes as a result of the removal of the dam were also reviewed to ensure that any increases in velocities upstream of the proposed rock ramp fishway and upstream grade control structure would not result in addition scour at upstream bridge locations. The following table illustrates changes in velocities during the 10-year and 100-year flood events at sections just upstream and downstream of the five bridges within the project limits where minor reductions in water surface elevations are proposed.

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Table 13: Flow Velocity Increases at Upstream Bridge Locations During 10- and 100-Year Flood Events

River Sta	Profile	Plan	Q Total (cfs)	W.S. Elev (ft)	Channel Velocity (fps)	Velocity Increase (fps)
99717.16	Q10	Pre-Conditions	1480.00	42.79	3.48	0.00
99717.16	Q10	Post-Conditions	1480.00	42.78	3.48	
99717.16	Q100	Pre-Conditions	2710.00	45.28	4.53	0.00
99717.16	Q100	Post-Conditions	2710.00	45.28	4.53	
99697.72 Amtrak Railroad Bridge #4						
99648.13	Q10	Pre-Conditions	1480.00	42.77	3.22	0.00
99648.13	Q10	Post-Conditions	1480.00	42.76	3.22	
99648.13	Q100	Pre-Conditions	2710.00	45.26	4.34	0.00
99648.13	Q100	Post-Conditions	2710.00	45.25	4.34	
86457.04	Q10	Pre-Conditions	2830.00	38.72	3.56	+0.02
86457.04	Q10	Post-Conditions	2830.00	38.67	3.58	
86457.04	Q100	Pre-Conditions	5170.00	41.30	4.64	+0.01
86457.04	Q100	Post-Conditions	5170.00	41.28	4.65	
86439.38 Burdickville Road Bridge						
86386.67	Q10	Pre-Conditions	2830.00	38.61	3.72	+0.03
86386.67	Q10	Post-Conditions	2830.00	38.56	3.75	
86386.67	Q100	Pre-Conditions	5170.00	41.03	5.07	+0.01
86386.67	Q100	Post-Conditions	5170.00	41.01	5.08	
83911.23	Q10	Pre-Conditions	2830.00	38.24	3.04	+0.02
83911.23	Q10	Post-Conditions	2830.00	38.18	3.06	
83911.23	Q100	Pre-Conditions	5170.00	40.35	4.49	+0.01
83911.23	Q100	Post-Conditions	5170.00	40.32	4.50	
83899.99 Amtrak Railroad Bridge #3						
83845.99	Q10	Pre-Conditions	2830.00	38.22	3.04	+0.02
83845.99	Q10	Post-Conditions	2830.00	38.16	3.06	
83845.99	Q100	Pre-Conditions	5170.00	40.32	4.48	+0.01
83845.99	Q100	Post-Conditions	5170.00	40.29	4.49	
69502.02	Q10	PreFinal	2980.00	35.98	3.42	+0.15
69502.02	Q10	Post-Conditions	2980.00	35.72	3.57	
69502.02	Q100	PreFinal	5450.00	38.58	4.36	+0.04
69502.02	Q100	Post-Conditions	5450.00	38.51	4.40	
69484.7 Amtrak Railroad Bridge #2						
69437.49	Q10	PreFinal	2980.00	35.92	3.46	+0.15
69437.49	Q10	Post-Conditions	2980.00	35.65	3.61	
69437.49	Q100	PreFinal	5450.00	38.47	4.47	+0.03
69437.49	Q100	Post-Conditions	5450.00	38.40	4.50	

River Sta	Profile	Plan	Q Total (cfs)	W.S. Elev (ft)	Channel Velocity (fps)	Velocity Increase (fps)
67124.53	Q10	PreFinal	2980.00	35.49	2.95	+0.09
67124.53	Q10	Post-Conditions	2980.00	35.17	3.04	
67124.53	Q100	PreFinal	5450.00	37.82	4.45	+0.03
67124.53	Q100	Post-Conditions	5450.00	37.73	4.48	
67107.58 Alton Bradford Road Bridge						
67040.16	Q10	PreFinal	2980.00	35.39	2.83	+0.09
67040.16	Q10	Post-Conditions	2980.00	35.07	2.92	
67040.16	Q100	PreFinal	5450.00	37.58	4.26	+0.03
67040.16	Q100	Post-Conditions	5450.00	37.49	4.29	

Given the relatively insignificant changes in flow velocities at upstream bridge locations, it was concluded that scour conditions would not be adversely impacted as a result of the removal of the Dam and the installation of a rock ramp fishway with upstream grade control structure.

Detailed results of the post-conditions hydraulic model are provided in *Appendix D*.

4.6 Flood Protection Benefit Summary

The removal of the Bradford Dam and construction of a rock ramp with upstream grade control structure will provide for adequate fish passage at the Dam while minimizing the reduction of upstream base condition water surface elevations and providing marginal reductions in extreme flood water surface elevations throughout, upstream, and downstream of the nature-like fishway.

Since this is a low-head dam located in a stretch of the River with a relatively flat hydraulic gradient, it is significantly impacted from backwatering affects from the Potter Hill Dam. As a result, dam removal with our without the incorporation of a rock ramp fishway would not provide significant flood protection benefits during the more significant flood events such as the 100-year flood. Noting the above, the project will result in minor reductions in flood elevations upstream of the existing Dam for a distance of approximately 7.1 miles upstream. Maximum reductions in 2-, 10-, 25-, 50-, 100-, and 500-year flood elevations of 0.29 feet, 0.24 feet, 0.32 feet, 0.19 feet, 0.14 feet, 0.09 feet, and 0.03 feet, respectively, is anticipated upstream of the Alton Bradford Road Bridge as reflected in *Table 14* in *Section 4.5.3* and on the hydraulic profile sheet included in *Appendix D*.

In summary, the project will provide minor improvements to upstream flooding conditions while eliminating the potential for a catastrophic dam failure or breach during future flood events.

4.7 Compensation for Loss of Flood Storage

This project involves the removal of the Dam and its replacement with a rock ramp fishway and upstream grade control structure that will be located primarily within the current headpond to minimize

impacts to floodplain storage. The top of the upstream grade control structure is proposed at the same elevation as the invert of the Dam's spillway to further avoid upstream increases in flood elevations.

The project also proposes the placement of an earthen barrier at the inlet of the millrace channel (approximately 350 cubic yards) and the placement of fill (approximately 1,320 cubic yards) along the foundation of the adjacent mill building on river left to better protect the structure during flood events. Construction of the rock ramp fishway will also result in the placement of approximately 1,000 cubic yards of fill material within the River's floodplain.

In spite of the placement of a total of approximately 2,675 cubic yards of fill material within the floodplain, the project also proposes the excavation of approximately 4,950 cubic yards of material from the floodplain. Therefore, the project will result in the net removal of approximately 2,275 cubic yards of material from the River's floodplain. This net reduction in material from the floodplain can be attributed to the amount of excavation required to construct the rock ramp fishway to proposed grade, the removal of the Dam and Denil fish ladder, and the overall widening of the River within the limits of the project to its 120- to 130-foot natural channel width.

In summary, river channel modifications will result in the net removal of 2,275 cubic yards of material from within the River and its floodplain.

5. Groundwater and Surface Water Supplies

Several wetland areas exist along the stretch of the River within the limits of this project as depicted on *Figure 2*. As stated in *Section 4.5.3* above, the replacement of the Dam with a rock ramp and grade control structure will not significantly impact water surface elevations upstream of the Dam. The width and invert of the low-level notch in the grade control structure has been designed such that reductions in water levels upstream of the Dam would be limited to six-inches or less under base flow conditions, which will support continued use of the Boat Launch and minimize alterations to flow past the Route 91 Bridge. This will also avoid ecological impacts to sensitive upstream wetland resource areas as well as significant impacts to upstream groundwater levels and surface waters.

The only location where base condition water surface elevations will change by more than six inches is within a 180-foot stretch of the River (within the Project's limit of disturbance) between proposed Weir 1 and Weir 6 of the rock ramp fishway. Since the majority of the fishway was located upstream of the existing Dam in order to avoid local increases in 100-year floodplain elevations, significant base condition water surface elevation drops were limited to this one on-site section of the River. Due to the hydric nature of the soils underlying the three adjacent swamps, it is not anticipated that groundwater flow characteristics will be significantly altered at this location either.

In summary, groundwater and surface water supplies will not be affected by this project.

6. Water Quality

Water quality in the Pawcatuck River watershed has steadily improved over the past decade as more stringent pollutant discharge regulations were adopted. In addition, the development of new technology

allows for better treatment of wastewater prior to its discharge. Although the windrows of visible garbage, textile processing dyes, and floating sewage are no longer seen, the waters of the Pawcatuck River retain a tea-brown coloration. The coloration of the water is often mistaken for water pollution but is, instead, a natural product of the breakdown of leaves and organic material from the heavily wooded regions of the watershed.

6.1 Drainage Characteristics

Approximately 17% of the land use within the Pawcatuck River watershed is classified as urban, and much of that area is concentrated around the impaired freshwater segment in Stonington, North Stonington, and Westerly. Urban areas typically contain impervious surfaces such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. There are several reported outfalls that were located in prohibited and restricted areas of the estuary, each of which can be considered as a potential bacteria source. Past studies have shown a link between the amount of impervious area in a watershed and water quality conditions (CWP, 2003).

According to *CTDEEP's CT Pawcatuck River Watershed Bacteria TMDL (2014)*, "The watershed is characterized by four impervious cover percentage ranges. The majority of the watershed (41%) is characterized by land with 0 to 6% impervious cover, while 28% of the land has 7 to 11% impervious cover, and 30% of the land is covered by 12 to 15% impervious. Less than 1% of the watershed is characterized by >16% impervious cover. Given the amount of impervious surfaces in the watershed and the proximity of those surfaces to the impaired segments, stormwater is a potential source of bacterial contamination to the Pawcatuck River and its tributaries and estuary."

The project will not result in impacts to surface flows discharged to the Pawcatuck River. Therefore, impacts regarding water quality will only be a result of temporary dam removal construction activities and will be limited to equipment access and materials staging areas in addition to the potential suspension of soils/sediment from excavation areas within cofferdammed limits. As outlined in the following section, temporary water quality impacts during construction will be minimized by both temporary and permanent soil erosion and sediment control measures.

6.2 Wetland Functions and Values

The Pawcatuck River, within the project limits, has a water quality classification of B1 as listed within *RIDEM's State of Rhode Island and Providence Plantations 2014 Integrated Water Quality Monitoring and Assessment Report, Section 305(b) State of the State's Waters Report, Section 303(d) List of Impaired Waters (May 2015).* This water classification indicates that these waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have good aesthetic value. Primary and secondary contact recreational activities are impacted (in this section of the River) by Enterococcus as stated within the *State of the State's Waters Report.* Additionally, this section of the River also has an impairment associated with supporting benthic-macroinvertebrate communities.

Recent studies conducted by several teams of University of Rhode Island researchers, in cooperation with RIDEM, have shown that the water in both the river and the estuary is generally of high quality, and provides healthy habitat for a wide variety of plants and animals. Concentrations of metals, such as lead, iron, copper, zinc, and nickel, have decreased over the past decade in waters entering the estuary from the Pawcatuck River. Although iron and lead are still present and considered to be an impairment in the section of the River downstream of the Project, these metals were not listed as impairments to the River within the project limits.

Nutrients, such as nitrogen and phosphorus, are abundant in the river and estuary. Runoff from fertilized agricultural and residential areas, sewage treatment facilities, and septic systems add nutrients to rivers, streams, and groundwater throughout the watershed. One effect of excess nutrients is algal blooms and fish kills, but there is no evidence to suggest that the estuarine portion of the watershed has, or is, suffering similar symptoms. A heavy growth of "fouling" organisms on the blades of eelgrass in Little Narragansett Bay has been suggested to be the result of excess nitrogen in the estuary, but further study is required to determine if the level of nutrients in the river and estuary is affecting aquatic life. Nitrogen and phosphorus were not listed as impairments to the River within the project limits.

Alternatively, data indicates that bacteria levels in these waters exceed the state's enterococci bacteria standards, which are established to be protective of swimming and other recreational uses, such as canoeing and kayaking. Potential sources of indicator bacteria in the Pawcatuck River include point and non-point sources, such as stormwater runoff, agricultural activity, failing septic systems, nuisance wildlife/pets, and illicit discharges to the waterbody.

Since the project does not proposed impacts to surface runoff, it is not anticipated that the Project will adversely impact the current functions and values of the River and its adjoining wetlands as it relates to its current impairments. The only potential water quality impacts would be through sediment transport. As a result, the rock ramp fishway and its sideslopes will be permanently stabilized with adequately sized stone armor protection in order to minimize erosion and sediment transport following construction.

6.3 Anticipated Impacts

6.3.1 River Channel Sediment Characteristics

This section will serve as the project's Sediment Management Plan (SMP) to identify measures to mitigate sediment exposure risks through establishment of procedures that will be implemented during the course of the project.

For the purposes of this SMP, "sediment" discussed in this document refers to accessible river channel sediment that is located within the project work area (i.e. just upstream and downstream of the existing Dam spillway and within the limits of the temporary upstream and downstream cofferdam systems).

Fuss & O'Neill conducted an investigation of the Pawcatuck River from the Amtrak Bridge crossing, which is approximately 17,100 feet upstream of the Bradford Dam, to the pumphouse located approximately 300 feet downstream of the Dam. The objective of the investigation was to assess the physical and chemical properties of the sediments, and to evaluate potential sediment mobility following

removal of the Dam. Sediment data collection was focused on those sediments with the greatest potential to be mobilized or excavated as a result of future removal of the Dam and installation of a rock ramp fishway.

In May 2014, Fuss & O'Neill personnel conducted preliminary observations of channel bed characteristics, which included probing the channel bed with a metal rod and obtaining qualitative measurements of bottom depths, thalweg placement and thickness of soft sediments encountered within the entire limits of the investigation area. On October 14, 2014, Fuss & O'Neill personnel conducted a more site-specific investigation of the River from a point approximately 800 feet upstream of the Dam to a point approximately 300 feet downstream of the Dam. The objective of this investigation was to characterize physical and chemical properties of sediment that could potentially become mobilized and/or re-used for in-river channel improvements.

The October 14th field investigation activities are described in the following paragraphs:

- *Sediment Sampling*: Six samples were collected from channel sediment within close proximity to the project limits that were suspected to be most at risk of being mobilized during a dam breach scenario. Three representative samples (designated SD-5, SD-6, and SD-14) were submitted to Premier Laboratory of Dayville, CT for laboratory analysis of the following parameters:
    - Priority Pollutant 13 Metals by USEPA 6010/7471
    - Semi-volatile Organic Compounds (SVOC) by USEPA Method 8270
    - Polychlorinated Biphenyls (PCBs) by USEPA Method 8082
    - Pesticides by USEPA Method 8081
    - Cyanide by USEPA Method 9014

  These parameters were selected based on pre-permitting consultations with RIDEM regulatory/permitting staff that occurred prior to the removal of the White Rock Dam (since samples at the Bradford Dam were obtained at the same time as those taken at the White Rock Dam). Refer to *Illustration 14* for a depiction of sediment sampling locations. All three of the samples submitted for laboratory analysis were collected upstream of the dam. Sample SD-5 was collected from soft sediment near the millrace inlet on river left at a depth ranging between 0 to 1 feet below grade. Sample SD-6 was collected upstream of the dam along the right riverbank near the right abutment of the Dam at a depth ranging between 0 to 1 feet below grade. Sample SD-14 was collected from soft sediment near a wetland complex upstream of the dam on river right across the river from the Bradford Boat Launch at a depth ranging between 0 to 4 feet below grade.
- *Visual Observations*: Additional visual observations of the project reach assessed exposed soils, grading, armor and vegetative cover on riverbanks and millrace channel bed and riverbank materials.

Data from these field investigations and assessments were used to generate a sediment facies sketch map of the River segment immediately upstream and downstream of the Dam where sediment mobilization would most likely be anticipated in the event of a dam breach. This map has been included as *Figure 6: Sediment Facies Map* and reflects the composition and distribution of the various types of sediment and channel bottom substrates observed within the River between the Amtrak Bridge and the pumphouse as summarized below.

- The majority of channel bed materials upstream and downstream of the Dam were characterized by sand, gravel, cobbles, and boulders.
- Vegetated sand and silt deposits are stored as mid-channel bars and islands in a few locations within the section of the natural river channel downstream of the Dam.
- Fine sediment deposits consisting of sand, silt, and organic material are located on both banks of the River upstream of the Dam and in a mid-channel bar upstream of the Boat Launch. These sediments, including those associated with the swamp wetland complex on river right, appear to have the highest potential for redistribution in the event of a full dam removal.
- Exposed rock (boulders or ledge) was observed in portions of the channel bed within the project reach. Ledge, boulders, and/or large cobble was also found immediately below the Dam spillway on river left.

While pollutant criteria for sediment have not been formally adopted in respective regulations for dredging projects, comparative assessments have been made with respect to direct exposure criteria for soils as contained in RIDEM Remediation Regulations. A table summarizing laboratory analytical results of sediment samples is included in *Appendix E*. A summary of results is provided below.

- Pesticides, PCBs, and cyanide were not detected above laboratory reporting limits in the three sediment samples.
- Several metals, two VOC, and nine SVOC were detected above laboratory reporting limits in the sediment samples.
- Analytical results that exceeded laboratory detection limits were compared with the RIDEM Residential Direct Exposure Criteria (R-DEC) and RIDEM GA Leachability Criteria (GA-LC). The laboratory results for two sediment samples were below the RIDEM GA-LC. One Sample (SD-5) exceeded the regulatory criteria for four SVOC for the RIDEM R-DEC.

These results are consistent with laboratory analytical results of sediment samples collected at Lower Shannock Falls, Kenyon Mills Dam and White Rock Dam, indicating that low levels of pollutants are likely ubiquitous in the Pawcatuck River.

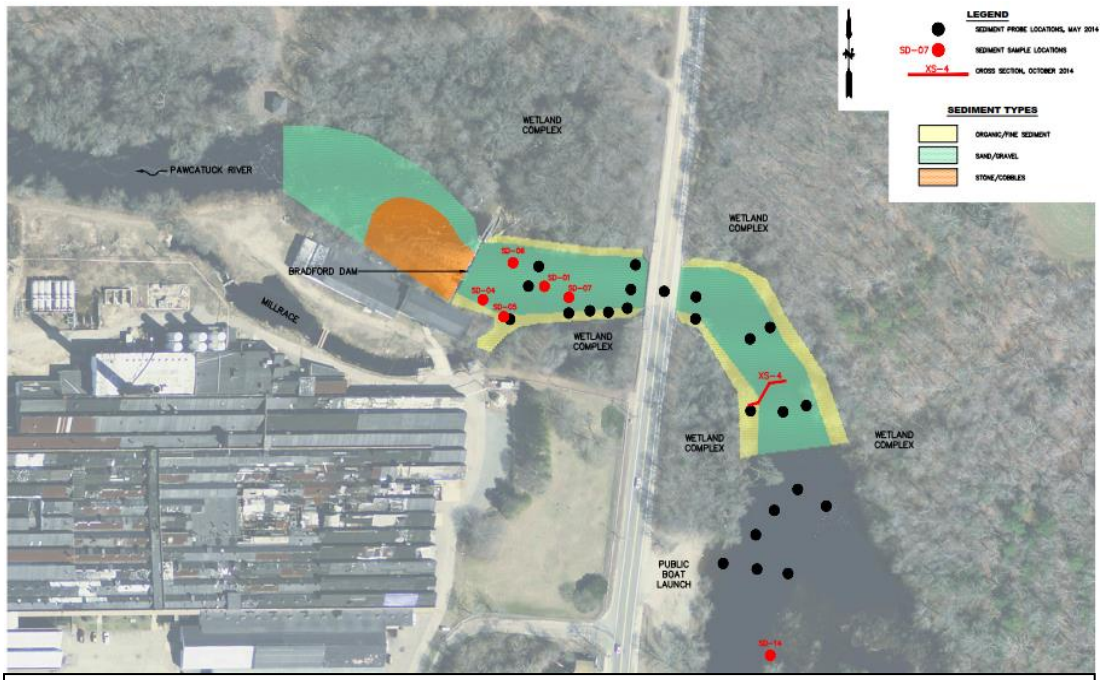

Illustration 14: Sediment Facies and Sample Location Map

6.3.2 Sediment Management

Sediment management is an important component of any dam removal project during construction. The Dam (located at River Sta. 66793.86) has a current spillway average elevation of El. 32.60± (NAVD88). The proposed project will remove the majority of the dam (with exception to left end where it abuts the existing mill building's foundation) as well as the concrete Denil fish ladder and any remnants of legacy dam structures located within the headpond. The Dam will essentially be replaced with a rock ramp fishway and upstream grade control structure, thereby maintaining a controlling weir elevation of approximately El. 32.54± feet (NAVD88) with a low-flow notch elevation of approximately 30.04'± (NAVD88). As a result, it is anticipated that the proposed upstream grade control structure will maintain any impounded sediment within the headpond that is upstream of the project's limit of disturbance. This will limit the amount of impounded sediment that will mobilize as a result of this dam removal project.

Based on the sediment characterization in *Section 6.3.1*, sediment to be excavated from the existing channel within the project's limit of disturbance will be used to construct in-river channel improvements (to the maximum extent practical) in the following designated locations:

- as fill within the proposed river channel where required to bring the existing channel bottom to proposed grade;
- as fill material for the void spaces associated with the stone slope and channel bottom armoring;
- as material to create the proposed Millrace cutoff barrier (though it is noted that any sediment excavated from the vicinity of SD-5 will be placed at least 2-feet below proposed final grade); and
- as fill placed along the left side of the proposed river channel (below the riprap) that will provide for improved flood protection to the foundation of the existing adjacent mill building;

Sediment that is excavated from locations outside of the existing streambanks will also be re-used for in-river channel improvements to the maximum extent possible. Any excess excavated sediment from area outside of the existing river channel that cannot be re-used in construction of the improvements shall be uniformly spread within the portion of the temporary staging/stockpile/storage area that is elevated above the 100-year floodplain.

The remobilization of sediment impounded behind dams can have physical (increased turbidity) and toxicological effects if contaminant levels exceed applicable thresholds. To minimize sediment transport during and following construction, the following measures have been proposed during construction:

- Perimeter erosion controls will be installed down-gradient of proposed temporary access routes and staging/storage areas as depicted on the *Demolition and Erosion Control Plans, Sheet CS- 104*.
- Temporary cofferdams will be installed upstream and downstream of work areas as reflected on the *Water Control & Construction Sequencing Plan, Sheet CP-101*. The cofferdam systems will be designed to maintain dewatered conditions within the work areas for storm events up to and including the 2-year recurrence interval storm event. These cofferdams will contain all sediment within the work areas during construction.
- Construction within the River, including the installation of in-river water control systems, will be limited to the seasonal low-flow period between July 1st to October 31st, with potential extension of the period of work beyond October 31st based on river levels at that time and the status of work in order to assure all project work is completed and the site suitably restored/stabilized before increased flows associated with the winter season occur. This will minimize the risk/potential of the work area being flooded during the construction period, when exposed sediment will be more susceptible to transport by erosion/scour.
- Temporary dewatering of work areas with discharge through filter bags/devices are proposed to avoid/minimize the amount of sediment discharged from dewatering pumps into the River.
- During construction, river flows will be diverted around work areas via a diversion channel.
- A turbidity curtain is proposed within the Millrace to prevent sediment transport within the freshwater pond while the millrace cutoff barrier is constructed.
- Vegetated soil-filled stone armor stabilization will be installed along the channel bottom and sideslopes (below the bankfull elevation) along the length of the rock ramp as well as locations on both riverbanks downstream of the rock ramp where the channel bends. This will minimize future erosion of these bank areas.
- Vegetated soil-filled stone armor stabilization is also proposed for the surface/upstream slope of the Millrace in the location of the proposed cutoff barrier. This will minimize erosion/scour along the face of the barrier, decreasing sediment in the water.

<u>Site Protection, Access and Staging</u>

- During excavation activities, the work area will be left in a secure and stable condition following each day of work.
- Heavy equipment used to excavate sediment will operate within the dewatered river channel to access respective removal areas. Access routes from riverbank areas will be field-evaluated once

the river channel is dewatered, to identify areas with a hard channel bottom that would not be subject to excessive rutting (i.e., rocky or exposed bedrock substrate, or firm sand/gravel). Equipment will be required to remain within these established routes and work areas to avoid rutting of other portions of the river channel (i.e., soft sediment and/or vegetation). If it is determined that heavy equipment must traverse areas with soft channel substrates outside excavation areas, these routes will be protected by temporary timber or geo-composite swamp mats.

- Equipment will be parked outside the riverbanks to prevent damage from potential high flows during non-work periods or leaks of hydraulic fluid, oil, etc. Equipment refueling will only occur outside the riverbanks; spill protection supplies will be stocked with equipment and/or fueling vehicles, as well as in an on-site job storage box/trailer.

Sediment Excavation and Backfilling

- Sediment excavation and re-location activities will commence following completion of dewatering activities within the work area. During periods of high river flows (or precipitation events expected to generate flows greater in magnitude than the 2-year recurrence interval flood event) that result in the cresting of the temporary cofferdam system or the sheet pile cutoff, additional temporary sandbags and pumps may be used to further dewater limited work areas or work will cease until river flows subside to levels below the top of overtopped water control systems. Water pumped from work areas will be discharged through dewatering areas (with filter bags) prior to being released into the diversion channel.

- Excavation of the sediment will be conducted using a tracked excavator. Accessible sediment within the work area will be excavated to achieve target elevations. Excavated sediment will be relocated onsite to construct the barrier across upstream end of the Millrace, or otherwise incorporated into streambank stabilization measures. Any sediment excavated from the immediate vicinity where SD-5 was collected will be used to create the core of the millrace barrier and will only be placed to within 2-feet below proposed final grade and as fill placed along the left side of the proposed river channel (below the 3-foot layer of riprap. This sediment management strategy is in accordance with beneficial re-use policies developed by RIDEM regarding low-level impacted soils and dredged sediment (as outlined in RIDEM's Rules and Regulations for Dredging and the Management of Dredged Material

To minimize water quality impacts (in terms of soil erosion and sediment control) as a result of dam removal, rock ramp construction, and associated in-river improvements; the project also proposes a combination of live stakes and seeding to minimize erosion and stabilize sediments. Bank areas above the anticipated base condition water surface elevation but below the bankfull (or 2-year) water surface elevation will be stabilized with soil-filled stone armor and live stake plantings.

Biodegradable coir rolls will be installed at the bankfull (or 2-year flood) water surface elevations along both sides of the River Bank areas above the anticipated bankfull water surface elevation will then be stabilized with seed and 100% long-term biodegradable erosion control blanketing. In order to expedite the stabilization of the site, the *In-Stream & Riparian Habitat Restoration Plan (Sheet CL-101)* reflects the installation of native species of seed mix and live stake plantings. Installing native seed and lives stakes will aid in countering the establishment of invasive species while providing valuable riparian habitat

subsequent of construction.

As documented in *Appendix F*, the USACE Bed Equation (1991) and the Abt and Johnson Equation (1991) were both used to size channel bottom and stone slope protection within the footprint of the rock ramp fishway (RS 66654.40 to RS66983.31). Based on the slope of the rock ramp fishway and the unit discharge expected through the fishway during the 100-year recurrence interval flood event, 'R-7' sized riprap was determined to be adequate for channel bottom and slope protection.

In designing proposed stabilization measures along the upper slopes (above the bankfull elevation), the results of the HEC-RAS model were reviewed to determine the velocity and shear stress anticipated at the project location. The following table presents the respective stability thresholds required for the proposed long-term erosion control blanketing. Details for bank stabilization in respective areas are identified on *Construction Details, Sheet CD-501*.

Table 14
Typical Stability Thresholds for Erosion Control Practices

Material	Threshold Velocity (ft/sec)	Shear Stress (lb/sf)
Biodegradable Blanketing (for 2:1 slopes)	8.0	3.0
Biodegradable Coir Roll (for 2:1 slopes)	8.0	3.0
Bare Soil (Sand, silt loam, muck)	2.0	0.5
Soil with Vegetation (good condition)	3.5	1.0

After reviewing the computed velocities and shear stresses through the rock ramp fishway for the various flood events, it was determined that the highest shear stresses and flow velocities would be experienced during the 10-year flood. A maximum flow velocity of 4.2 feet per second and a maximum shear stress of 0.52 lb/sf were computed. As a result, the proposed upper slope stabilization blanketing has been selected to meet the respective velocity and shear stress threshold values reflected above.

7. Impact Minimization and Avoidance

Rule 10.02 D of the Rules requires applicants seeking permission to alter a freshwater wetland to detail the ways in which this project may avoid impacts to the resource areas. The purpose of this project is to improve the wildlife and fisheries habitat associated with the Pawcatuck River through the removal of the existing Bradford Dam and installation of a nature-like rock ramp fishway. As such, this project is water dependent and requires access to and work within the jurisdictional wetlands in order to perform the outlined work.

Planning and design of this dam removal and rock ramp fishway construction project has been developed in close coordination with RIDEM Division of Fish and Wildlife staff, who are participating partners, along with other federal agencies, in this project. A detailed HEC-RAS modeling analysis was performed, as described above, to evaluate alternative project approaches that achieve effective fish passage through the site without causing an increase of 100-year base flood elevations or reductions in base flow that will impact freshwater wetlands. The selected alternative from this evaluation was subsequently developed

into the design and proposed project activities reflected on the drawings and described within this application narrative.

7.1 Impact Avoidance

In accordance with Rule 10.02D (1) of the Regulations, the applicant has addressed the six criteria concerning impact avoidance. The responses below correspond alphabetically to each of these criteria.

a) *Whether the primary proposed activity is water-dependent or whether it requires access to freshwater wetlands as a central element of its primary purpose (e.g., a pier);*

Due to the nature of this project to improve fish passage along the Pawcatuck River, the project is water dependent as it requires access to and work within the Pawcatuck River as its primary purpose. The proposed alterations within the swamp located to the north of the river are required to provide access to and from the temporary staging/storage/stockpile area.

b) *Whether any areas within the same property or other properties owned or controlled by the applicant could be used to achieve the project purpose without altering the natural character of any freshwater wetlands;*

This project is both wetland and location dependent being that it requires access to Bradford Dam and those banks located upstream and downstream of this feature. Due to the width of the Pawcatuck River, all work cannot be conducted solely from a single bank while reaching across the river's entire width.

In regards to the swamp crossing, the surrounding area is either developed or vegetated and cannot support the presence of construction machinery, vehicles or soil stockpiles without interfering with the normal activities of the area. The previously disturbed upland clearing will be used to fulfill these needs, minimizing the impacts through the swamp to the use of a temporary path through the swamp allowing access to and from the project area. Temporary construction access to the Project Site and the existing Dam is the minimum necessary to allow completion of the project.

Based upon these factors, there are no alternate locations that can be used to achieve the project goals while providing a greater level of impact avoidance.

c) *Whether any other properties reasonably available to, but not currently owned or controlled by, the applicant could be used to achieve the project purpose while avoiding wetland alterations. A property is reasonably available if, in whole or in part, it can be acquired without excessive cost, taking individual circumstance into account, or, in the case of property owned or controlled by the same family, entity, group of affiliated entities, or local, state or federal government, may be obtained without excessive hardship;*

As noted above, the wetland and location-dependent nature of this project prohibits the use of alternative, off-site locations that could potentially provide a greater level of impact avoidance. As the swamp occurs along the northern (right) bank in the immediate vicinity of the dam, any access to the intended project area will require some level of wetland alterations. Some limited avoidance can be achieved by utilizing an existing pathway as the temporary access road to the river's northern bank. This will allow the temporary road to fall partially within the non-jurisdictional uplands.

d) Whether alternative designs, layouts or technologies could be used to avoid freshwater wetlands or impacts on functions and values on the subject property or whether the project purpose could be achieved on another property that is reasonably available and would avoid wetlands;

The current project design, layout, and technologies were all chosen for their ability to avoid alterations to freshwater wetlands to the greatest extent practicable while still achieving the project's goals. Several iterations of design and hydraulic analyses have determined that the improvements proposed are the minimum necessary to achieve the project goals of flood reduction and effective fish passage immediately following construction. All work will be conducted during the summer months when the Pawcatuck River exhibits its historic low flow. Furthermore, property erosion and sedimentation controls will be installed and maintained during the construction process.

Due to the location-dependent nature of the project, the project purpose could not be achieved on another property.

e) Whether the applicant has made any attempts (and if so what they were) to avoid alterations to freshwater wetlands by overcoming or removing constraints imposed by zoning, infrastructure, parcel size or the like;

The alterations that are proposed within state jurisdictional wetlands cannot be further avoided by zoning, infrastructure, parcel size or other related constraints. Instead, such activities are due solely to the wetland and location-dependent nature of this project, and the necessity of accessing and working within the banks of the Pawcatuck River to achieve the project goals.

f) Whether the feasible alternatives that would not alter the natural character of any freshwater wetlands on the subject property or on property that is reasonably available, if incorporated into the proposed project, would adversely affect public health, safety or the environment.

Neither the current design, nor any known alternatives, will result in an adverse consequence to public health, safety, and/ or the environment. There are no alternatives that have not been incorporated into the project that, if utilized, would also achieve the same project purpose while providing a greater level of impact avoidance. As proposed, this river improvement project will not result in a significant adverse consequence to the public health, safety, and/or the environment

7.2 Impact Minimization

Due to the location-dependent nature of the project, the complete avoidance of the wetland features cannot be achieved. As such, the project has been designed to minimize wetland impacts to the greatest degree practicable. The majority of all work within the swamp and its perimeter wetland will be temporary in nature to support access to the stockpile area. Once the rock ramp has been installed and stabilized, the temporary access road shall be appropriately seeded and/or planted to allow the area to revert back to its natural state.

Although the conversion of the Dam into a rock ramp will require some temporary work within the River, this project will restore it to a more natural state. Once the project is completed, the River will remain as a natural riverine corridor that will provide a greater value for fish passage. The rock ramp and grade control structure shall allow this to be accomplished without compromising the naturally vegetated communities upstream of the dam by maintaining a similar water elevation. Measures have been included

to repair and maintain current areas of scouring and/or erosion along the River's northern (right) bank to help protect the River from future degradation.

The following information addresses each of the four (4) concerns outlined in Rule 10.02D (2) regarding minimization:

a) *Whether the proposed project is necessary at the proposed scale or whether the scale of the wetland alteration could be reduced and still achieve the project purpose;*

No reduction in the project's scale is possible without compromising the overall goals of removing the dam and replacing it with a rock ramp fishway that will provide safe and effective fish passage. The current scale is dictated by the primary goals, which include the removal of the Dam and construction of a new grade control structure and rock ramp fishway. This feature shall allow for fish passage along this portion of the Pawcatuck River while minimizing upstream water elevation changes. The scale of the fishway (in terms of length) is the minimum scale necessary to meet NOAA's latest recommended fish passage design requirements for rock ramp fishways in terms of spacing between weirs (or pool lengths) and maximum vertical hydraulic drops across weirs. Both of these criteria dictate the length of the fishway.

b) *Whether the proposed project is necessary at the proposed location or whether another location within the site could achieve the project purpose while resulting in less impact to the wetland;*

As previously noted, there are no alternate locations available that would achieve the project goals while allowing for a greater level of impact minimization. The goals of this project are both location and wetland dependent in that they require access to the Pawcatuck River and the nearby cleared area for temporary use as a temporary staging/storage/stockpile area. The temporary access road is essential in that it will provide access to and from the northern bank of the river from the stockpile area.

c) *Whether there are feasible alternative designs, layouts, densities or technologies, that would result in less impact to the wetland while still achieving the project purpose; and*

There are no alternate designs, layouts or technologies that could be employed that would result in a greater reduction to the potential wetland impacts. All work has been minimized to the greatest extent practicable while still maintaining the intended project goal of replacing the dam structure with the proposed rock ramp to provide for safe and effective fish passage while avoiding impacts to sensitive upstream wetland resources and flood elevations. Because most of the proposed work shall require only temporary disturbances, the project design will allow for no long-term impact to the freshwater wetlands. In fact, the replacement of the existing dam with the proposed structures will serve to restore river continuity and improve wetland habitat functions and values through the facilitation of upstream movement of resident and migrating fish populations that historically existed prior to construction of the Dam.

d) *Whether reduction in the scale or relocation of the proposed project to minimize impact to the wetland would result in adverse consequences to public health, safety, or the environment.*

The current project scale and location have been carefully studied and chosen to ensure that they would cause no detrimental impacts to public health, safety or the environment. As designed, this project will not result in significant decreases in upstream dry-weather water levels that could impact sensitive upstream wetlands and will not result in increases to flood elevations. In fact, minor reductions in flood elevations will be realized for several miles upstream of this project.

It is our opinion that the applicant has minimized the impact to the perimeter wetland to the greatest extent possible. The shape of the lot, in combination with the presence of DEM jurisdictional wetlands, presents the challenge faced by the applicant in minimizing potential impacts.

7.3 Mitigation Measures

In accordance with Rule 10.02D (3), the applicant has attempted to mitigate any potential impacts that may result from this project. Besides utilizing design methods to avoid and minimize potential impacts to state jurisdictional wetlands, this project has also proposed the implementation of the requisite and appropriate mitigating measures.

The applicant has proposed a series of erosion and sedimentation control measures that shall be established along all limits of disturbance associated with this project. These erosion controls are depicted on the *Demolition and Erosion Control Plan, Sheet CS- 104*. All erosion control measures will remain in place throughout all construction activities; in addition, these features shall be monitored on a regular basis throughout the construction process. Strict utilization of these erosion controls should ensure that neither erosion nor sedimentation potentially occur during the removal of the dam's features and the construction of the rock ramp fishway.

The project is to be completed in designated phases, allowing for the proper installation of cofferdams so that the flow of the Pawcatuck River will not be restricted. Instead, water will pass through a diversion channel on the north (right) bank of the river. This construction method will thereby ensure the continued and unimpeded flow of the river during the entirety of the construction process.

In regards to the swamp crossing, temporary matting will be employed to allow for the passage of equipment and machinery to and from the stockpile area. The engineer has designed the placement of the matting to protect the wetland from this temporary use. The silt fence shall extend through to this crossing to prevent erosion and sedimentation from occurring within the swamp. When the project is completed, the area will be revegetated as depicted on the *In-Stream & Riparian Habitat Restoration Plan, Sheet CI-101*.

As shown on the *Water Control & Construction Sequencing Plan (Sheet CS-114)*, following completion of the dam removal and associated in-river channel improvements, the cofferdam systems will be removed in a controlled manner that limits drawdown rates for the water impounded upriver in order to prevent potentially erosive flow rates. Exposed sediment areas along the riverbank (above the water level), and within the Project's limit of disturbance, will be stabilized through installation of 100% biodegradable coir rolls, blanketing, and/or matting and the establishment of riparian vegetation along the riverbank.

In addition to the mitigation measures above, the project engineer has opted to leave some existing retaining walls in place along the southern bank of the river. Any concrete or stone walls to remain have been indicated on the *Demolition and Erosion Control Plan, Sheet CS- 104.*

8. Conclusions

The following addresses the Review Criteria detailed in Rule 10.05 of the Rules and Regulations, in order to illustrate that the proposed project would not result in an adverse alteration to the natural characteristics of the affected wetland, or any of the related wetland functional values.

1) *Significant reduction in the overall wildlife production or diversity of a wetland;*

The replacement of the Dam with the proposed rock ramp and grade control structure will improve wetland habitat functions and values through the facilitation of the upstream and downstream movement of resident and migrating fish populations via removal of the man-made impediment. This project will not adversely affect wildlife production or the diversity of adjacent wetland communities.

While the access route to the northern (right) bank of the River and work along its banks to construct the rock ramp will entail temporary disturbances to state jurisdictional wetlands, and permanent modifications to the river/channel (rock ramp, water elevation) and the river banks (vegetated, fabric-reinforced soil layers and stone toe protection) will occur, these changes will not reduce wildlife habitat, utilization, or production as the River as the stabilized post-construction configuration will be similar in character and provide the same or improved functions as exists currently. Further, fish passage through the site will provide improved opportunities for wildlife catching fish as forage items.

Wetland resources upstream and downstream of the project are not expected to be negatively impacted by changes in water elevation. The only location where permanent changes to wetlands will occur, are in the immediate location of the River where the rock ramp and grade control structure will be installed. The rock ramp will raise the channel bottom in order to facilitate fish passage to the upstream side of the Dam. Approximately 6,400 square feet of Swamp will be converted to riverine habitat as a result of excavation that is proposed along the right bank of the River adjacent to widen the River to its natural width of 120 to 130 feet.

Disturbed areas on the banks of the River will be restored with stable vegetation and allowed to revert to a wild/native and natural state. In addition, the vast majority of existing vegetative cover will remain intact and undisturbed. The limited, selective vegetative cutting that is required along a preexisting cart path will be only temporary in nature, thus allowing these affected areas to continue to provide potential wildlife habitat in the long term.

2) *Significant reduction in the ability of a wetland to satisfy the needs of a particular wildlife species;*

This habitat improvement project is not expected to reduce the ability of the surrounding or upstream wetlands to satisfy the needs of any particular wildlife species. Most wetland impacts, with the exception of those occurring within the river and portions of the northern riverbank, will be temporary in nature. Upon completion of construction these areas will be restored and allowed to

revert to a natural condition, which will be similar to what existed prior to commencement of the project and should provide similar functions.

Also, no major changes in hydrology are expected as a result of this project; thus, no shifts in species composition and/or loss of habitat functions and values of existing wetlands are expected based upon the modeled changes in hydrology. This project will enhance habitat functionality and nutrient transport by facilitating the production and movement of anadromous, catadromous, and resident fish species through this wetland system, as well as providing micro-habitat for invertebrates and other benthic animals within the varied flow regimes at difference portions of the rock ramp.

3) *Significant displacement or extirpation of any wildlife species from a wetland or surrounding areas due to the alteration of the wetland;*

This project will neither significantly displace nor extirpate any current wildlife species associated with the site. As previously discussed, most impacts will be temporary in nature and associated with the construction process. Those areas of wetland altered in order to access the northern bank of this waterway will return to wild and vegetated habitat. This remaining and restored habitat will continue to provide habitat for current species.

Upon project completion, the ability of fish species that historically migrated upstream and downstream through this portion of the River will be significantly improved. The project will also likely better facilitate movement of resident fish species. Therefore the construction of the proposed fish passage structure will provide more effective fish passage for the anadromous and catadromous target species as well as resident species and other wildlife species utilizing the River. As such, wildlife diversity is expected to improve from current levels upon project completion.

4) *Any reduction in the ability of the wetland to ensure the long-term viability of any rare animal or rare plant species;*

Rare, endangered, and threatened animal and plant species have been historically observed within the natural heritage area located approximately 3,500 feet upstream of the Bradford Dam (reflected in Figure 4). As confirmed through hydraulic modeling, the current proposal will result in minimal reductions in base condition water levels upstream of the project area (of six inches or less). As such, it is not anticipated that there will be any adverse ecological impacts to upstream resource areas and that there will be no adverse or significant impact to any such species

5) *Any degradation in the natural characteristic(s) of any rare wetland type;*

No rare wetland type is present within the immediate project area. Those wetlands directly affected by the proposed project improvements include three swamps and a perennial river (as reflected on *Figures 2 and 3*). Neither of these particular features represents a rare or unusual wetland type.

There is, however, a wetland complex located 3,500 feet upstream of the Dam that is considered a coastal plain quagmire (state critically impaired and globally vulnerable), coastal plain floodplain swamp (state critically imperiled), acidic level fen (state imperiled), and acid level bog (state vulnerable). These habitat areas play a key role in supporting known species of state-endangered plants, including Podgrass (*Scheuchzeria palustris*), Swamp Pink (*Arethusa bulbosa*), and Horned Rush

(*Rhynchospora inundata*); as well as a state threatened plant: Two-flowered Bladderwort (*Utricularia biflora*); and many state concern plants: Dwarf Huckleberry (*Gaylussacia dumosa*), Goat's Rue (*Tephrosia virginiana*), Sundial Lupine (*Lupinus perennis*), Zizgzag Bladderwort (*Utricularia subulata*), Spike Rush (*Eleocharis equisetoides*) and Grass-pink (*Calopogon tuberosus*). The fishway's upstream grade control structure has been designed to limit upstream reductions in base flow condition water levels to six inches or less. This will allow such rare wetland communities to remain unaffected by this project.

6) *Significant reduction in the suitability of any wetland for use by any resident, migratory, seasonal, transient, facultative, or obligate wildlife species, in either the short- or long-term as a travel corridor; feeding site; resting site; nesting site; escape cover; seasonal breeding or spawning area;*

Due in part to the temporary nature of most of the proposed wetland alterations, no significant reduction in the suitability of any freshwater wetland by wildlife species for nesting, resting, feeding , breeding, escape cover, or other related values is expected to result from this project. As most of the proposed alterations within the swamp will be limited to temporary disturbance, these areas will remain or return to a natural and vegetated state following project completion and thus will continue to provide vegetated cover suitable for nesting, resting, feeding and breeding habitat, as well as for escape cover against predation, as relatively current levels.

Replacement of the Dam with a rock ramp and grade control structure will improve the habitat provided by this portion of the River for wildlife, fish and other water-dependent species. Once the structure is constructed, resident and migratory fish species, as well as other aquatic species, will be able to migrate upstream and downstream where previously their migration was prevented by the dam structure. Although some wildlife species (e.g., small and medium mammals; birds) may be temporarily displaced from the staging and access areas associated with the construction process, not all potential species will be affected, and impacts will not continue beyond completion of the proposed work. Also, it is expected that a majority of the habitat within the identified limit of disturbance will still be available for use (e.g., travel, feeding, resting, etc.) by wildlife throughout construction when disturbance and human presence are absent or minimal. In addition, no wetland habitat will be degraded and made unsuitable as a result of this project, or become entirely unavailable to wildlife.

7) *Any more than a minimal intrusion of, or increase in, less valuable, invasive or exotic plant or animal species in a wetland;*

This project will not result in more than a minimal intrusion by or increase in less valuable, invasive, or exotic plant or animal species. That portion of the River that is subject to the rock ramp installation will continue to provide all current riverine functions and values. By seeding and replanting those areas of swamp affected by the installation of the temporary access road with native plant species, the potential for invasive plant species to successfully colonize this area will be significantly reduced.

The new species that are anticipated to enter the immediate project area are not invasive in nature, but fish and other water-dependent species will be able to travel further upstream than is currently allowed. The otherwise undeveloped nature of the swamp found along the northern river bank should therefore promote the continued use of this area by native wildlife species.

8) *Significant reduction in the wildlife habitat functions and values of any wetland which could disrupt the management program for any game or non-game wildlife species carried out by state or federal fish, game, or wildlife agencies;*

The project has been designed to avoid significant reductions in wildlife habitat functions and values. The fishway's upstream grade control structure has been designed to limit upstream reductions in base flow condition water levels to six inches or less in order to avoid ecological impacts to upstream wetland resource areas. Therefore, wildlife habitat functions and values associated with wetland systems upstream of the project site (i.e. those systems bordering the Grills Preserve and Burlingame Management Area) will not be affected by this project.

9) *Significant reduction in overall current or potential ability of a wetland to provide active or passive recreational activities to the public;*

This project will not cause a significant reduction to any wetland's current or potential ability to provide active or passive recreational activities. The replacement of the Dam with a rock ramp and grade control structure, the repair and stabilization of the current non-designated canoe portage route along the river's northern edge, and improvement of fish mobility within this waterway is anticipated to improve a variety of recreational values. The creation of an improved location for an informal portage route alone will enhance the ability of small water craft to move up and along this perennial waterway. This improved location for portage will also support such activities by providing an easy and safe means for canoes and kayaks to move around the proposed grade control structure and rock ramp.

Also, the construction of a rock ramp and grade control structure is anticipated to increase the number and variety of fish and other water-based species both in the immediate portion of the River and those areas located further upstream. The increase presence of such species could also improve recreational fishing along this waterway.

10) *Significant disruption of any on-going scientific studies or observations;*

No current scientific studies are known to exist within the project area, or the immediate vicinity. As such, this project will not interfere with any on-going scientific studies.

11) *Elimination of, or severe limitation to traditional human access to, along the bank of, up or down, or through any rivers, streams, ponds, or other freshwater wetlands;*

No traditional human access ways would be affected by the proposed removal of the Dam. The removal of the Dam will significantly improve water-based access within and along the river by small canoes and kayaks by removing this man-made structure that obstructs the River and passage by boaters.

Some existing human access ways have been identified in close proximity to the River and the existing Dam location. This includes an existing pathway that passes in close proximity to the northern bank of the river and has previously been used to access the site for construction and repairs of the fish

ladder adjacent to the Dam. This pathway will be used for temporary construction access to the site. The River, itself, also represents a historic access way.

As noted above, the goal of this project is to facilitate upstream fish passage by replacing the existing Dam, which currently serves as an impediment to river travel, with a grade control structure and rock ramp. The grade control structure will be constructed with a ten-foot wide low-level notch to facilitate fish passage. Furthermore, the existing non-designated canoe portage route will be stabilized along the northern bank of this waterway following construction, and thus will continue function as a portage route for small personal water craft passing around the proposed rock ramp structure. The portion of the pre-existing road that will be temporarily improved for construction access to the project site will also be restored to its current natural state upon the project's completion. These design factors will thereby maintain or improve all historic access ways associated with the proposed project location.

12) *Any reduction in water quality functions and values or negative impacts to natural water quality characteristics, either in the short- or long-term, by modifying or changing: water elevations, temperature regimes, volumes, velocity of flow regimes of water; increasing turbidity; decreasing oxygen; causing any form of pollution; or modifying the amount of flow of nutrients so as to negatively impact wetland functions and values;*

This project has been carefully designed to avoid long term reductions in water quality functions and values, or negative impacts to water quality characteristics. Pools will be provided between proposed weirs to dissipate energy created by minor hydraulic drops (of 10 inches or less) in the rock ramp system. A stone tailout is also proposed at the downstream end of the rock ramp to provide a stable transition between the rock ramp and existing channel bottom.

All river bank areas impacted by construction will be stabilized with soil-filled stone armor protection or erosion control blanketing vegetated with native seed mixes and/or live stakes. This should improve the stability of the river bank areas within the project site that are currently experiencing erosion or slope degradation.

This project will also ensure that short-term impacts to water quality are minimized. As detailed on the accompanying site plans and construction sequence notes, the diversion channel outlet and to the River downstream of the Dam and the receiving area of streambed will be will be lined and protected by stone to ensure that it is capable of handling the temporary change (diversion) in water flow.

13) *Any placement of any matter or material beneath surface water elevations or erection of any barriers within any ponds or flowing bodies of water which could cause any hazards to safety;*

While construction of the rock ramp with grade control structure would place material beneath the current surface water elevation, this limited structure is not anticipated to cause any hazards to safety. The rock ramp has been designed to reduce flow velocities and energy across the system. Each weir within the rock ramp has been designed with a 10-foot wide low level notch (as well as two five-foot wide upper level notches) that would allow passage for recreational users during all flow conditions. A non-designated canoe portage route is also proposed along the northern (right) bank of the River to provide recreational boaters the option to bypass the system for safety purposes.

14) Significant loss of important open space or significant modification of any uncommon geologic or archaeological features;

No significant loss of open space is proposed. Furthermore, no uncommon geologic or archaeological features have been directly observed or are identified by the RIGIS data layers in association with the immediate project area. The USFWS is the lead federal agency implementing compliance activities under Section 106 of the National Historic Preservation Act with RI SHPO and THPO.

15) Significant modification to the natural characteristics of any wetland area of unusually high visual quality;

This project would not result in any alteration to a freshwater wetland of unusually high visual quality. Those wetlands found along the southern side of the River will be subject primarily to temporary disturbances associated with the construction of a temporary project access road. Upon the project's completion, temporary measures will be removed and the affected areas will be allowed to revert to their current natural and vegetated state. The work that is proposed within or along the immediate banks of the River is already occupied by or in close proximity to the existing Dam, which is a deteriorating concrete and stone structure, the replacement of which with a nature-like rock ramp fishway is expected to improve the visual quality of the site.

16) Any decrease in the flood storage capacity of any freshwater wetland which could impair the wetland's ability to protect life or property from flooding or flood flows;

No decrease in flood storage capacity is proposed within the Pawcatuck River or its adjacent wetland areas. The project actually proposes the net removal of approximately 2,275 cubic yards of sediment and/or channel material from within the river system and its bank areas. As a result of the removal of the Dam and other in-river channel improvements proposed, the project will result in the decrease in water surface elevations both upstream and immediately downstream of the Dam (subsequent to removal) during the overbank flood protection events. Specifically, reductions in 100-year base flood elevations (BFEs) are anticipated from the bottom weir in the rock ramp structure up to a point approximately 7.1 miles upstream of the Bradford Dam (up to the King's Factory Road Bridge).

As a result, flooding conditions within and adjacent to the River both upstream and immediately downstream of the Dam will be improved during the overbank flood protection storm events. For purposes of this Project and in accordance with the *Rhode Island Stormwater Design and Installation Standards Manual (December 2010)*, the overbank flood protection events are those storm events that result in riverbank overtopping that can cause flood damage and other impacts to adjacent properties; and are defined as storms of a magnitude that are equivalent to, or greater than, the 10-year recurrence interval flood event.

Therefore, overbank and bordering wetland areas directly along the River at the project site and upstream will remain unaffected and will continue to be available for flood storage. This project would not result in any decrease in the flood storage capacity of any such freshwater wetland which could impair the wetland's ability to protect life or property from flooding or flood flows as it is not changing the elevation of any freshwater wetlands.

In conclusion, no decreases in the flood storage capacities of adjacent freshwater wetlands upstream and downstream of the project are anticipated as water levels impacts during flood events are

minimal.

17) Significant reduction of the rate at which flood water is stored by any freshwater wetland during any flood event;

This project would not result in significant reduction of the rate at which flood water is stored by any upstream, on-site, or downstream freshwater wetland systems during any flood event. The project does not propose increases in water surface elevations during flood events. Additionally, the reconstruction of the right top of bank of the River within the project limits has been designed to match current top of bank elevations (to the maximum extent practical) such that the adjacent existing Swamp to the north of the fishway will continue to provide the same flood storage characteristics when water levels in the River rise and overtop the River's right top of bank.

18) Restriction or significant modification of the path or velocities of flood flows for the 1-year, 10-year, or 100-year frequency, 24-hour, Type III storm events so as to cause harm to life, property, or other functions and values provided by freshwater wetlands;

This project would not result in restriction or significant modification of the path or velocities of flood flows for the 2-year, 10-year, 25-year, or 100-year frequency, 24-hour, Type III storm events so as to cause harm to life, property, or other functions and values provided by freshwater wetlands as described in *Section 5.3.2*.

The project will not significantly affect water surface elevations or velocities upstream and downstream of the rock ramp. The only location where flow regime will be modified (i.e. water surface elevations and velocities) is in the vicinity of the rock ramp. The construction of the rock ramp will eliminate the significant drop in water elevation that currently exists immediately downstream of the Dam and thereby allow for fish passage via a series of smaller, manageable hydraulic drops. In order to avoid significant increases in water surface elevations and velocities that could potentially occur by proposing a rock ramp fishway downstream of a dam, the majority of the fishway was designed within the headpond upstream of the Dam. Siting the rock ramp fishway upstream of the Dam allows for the gradual transition between headwaters and tailwaters to occur prior to reaching the downstream side of the Dam. This avoids increases in flood elevations that would normally occur with a rock ramp fishway if it were proposed downstream of the Dam.

Only two of the eight rock weirs associated with the rock ramp fishway were proposed downstream of the former Dam. This was due to the limited distance between the existing Dam and RIDOT State Highway property lines associated with the Alton Bradford Road Bridge. These two downstream weirs, however, do not result in increases in flood elevations due to the backwatering impacts that the Potter Hill Dam currently has on tailwater elevations experienced downstream of the Bradford Dam during the more significant flood events. Excavation was also proposed downstream of the Dam to not only create 4-foot deep pools in between the weirs for fish passage and energy dissipation purposes, but also to assist in avoiding increases in tailwater flood elevations immediately downstream of the Dam.

Consequently, these changes will not result in an increased frequency of flooding during the flood events analyzed or cause harm to life, property, or other functions and values provided by adjacent freshwater wetlands, as outlined below.

19) Placement of any structure or obstruction within a floodway so as to cause harm to life, property, or other functions and values provided by freshwater wetlands;

The top elevation of the fishway's upstream grade control will be set to the approximately invert of the Dam's lower spillway crest, and therefore, will not cause harm to life, property, or other functions and values provided by freshwater wetlands upstream of the Dam.

The rock ramp, which will also be installed within the River's floodway, will not increase water surface elevations within the project area during flood events, nor will flooding frequency be increased within adjacent facility along the southern (left) bank of the River in the vicinity of the rock ramp. Thus, the placement of the rock ramp will not cause harm to life, property, or other functions and values provided by freshwater wetlands along the southern (left) side of the River.

20) Any increase in run-off rates over pre-project levels or any increase in receiving water/wetlands peak flood elevations for the 1-year, 10-year, or 100-year frequency, 24-hour, Type III storm events which could impair the wetland's ability to protect life or property from flooding or flood flows;

This project will not result in an increase in run-off rates over pre-project levels. This project will also not result in increases in peak flood water surface elevations during flooding events upstream, throughout, and downstream of the proposed project.

21) Any increase in run-off volumes and discharge rates which could, in any way, exacerbate flooding conditions in flood-prone areas;

This project does not propose any alterations in surface runoff volumes or discharge rates. Consequently, flooding conditions in flood-prone areas along the river will not be exacerbated.

22) Significant changes in the quantities and flow rates of surface or groundwater to or from isolated wetlands (e.g., those wetlands without inflow or outflow channels);

No isolated wetlands are present within the project area, nor would any such wetlands be affected by this habitat improvement project. All on-site wetlands that are subject to proposed alterations are hydraulically connected via the River.

23) Placement of any structural best management practices within wetlands, or proposal to utilize wetlands as a detention or retention facility;

No wetlands will be utilized as a detention or retention facility. Temporary structural best management practices will be used for soil erosion and sediment control during the course of construction as denoted in the site plans. Permanent structural best management practices will include, but are not limited to, the replacement of the Dam with an upstream grade control structure and rock ramp fishway in addition to channel and bank stabilization measures including stone armor channel bottom and slope protection.

24) Any more than a short-term decrease in surface water or groundwater elevations within any wetland;

No significant temporary or permanent reductions or decreases in surface water or groundwater elevations with any on-site or bordering wetland are anticipated.

25) Non-compliance with the Rhode Island Department of Environmental Management Water Quality Regulations;

Based on previous discussions with RIDEM's Water Quality Certification staff, this application will be reviewed under the Water Quality Certification program. Copies of the application will be provided as required for this purpose.

26) Any detrimental modification of the wetland's ability to retain or remove nutrients or act as natural pollution filter.

The proposed project will not result in a significant reduction in existing vegetative cover. The vegetated corridor that exists along much of the River's surrounding length will remain intact, and capable of retaining and/or removing nutrients, and acting as a natural pollution filter.